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Quantity and separation distances

UN SaferGuard
Securing ammunition, protecting lives

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Warning

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Foreword

Ageing, unstable and excess conventional ammunition stockpiles pose the dual risks of **accidental explosions at munition sites** and **diversion to illicit markets**.

The humanitarian impact of ammunition-storage-area explosions, particularly in populated areas, has resulted in death, injury, environmental damage, displacement and disruption of livelihoods in over 100 countries. Accidental ammunition storage area detonations count among the largest explosions ever recorded.

Diversion from ammunition stockpiles has fuelled armed conflict, terrorism, organised crime and violence, and contributes to the manufacture of improvised explosive devices. Much of the ammunition circulating among armed non-State actors has been illicitly diverted from government forces.[1] In recognition of these dual threats of explosion and diversion, the General Assembly requested the United Nations to develop **guidelines for adequate ammunition management**.[2] Finalised in 2011, the International Ammunition Technical Guidelines (IATG) provide voluntary, practical, modular guidance to support national authorities (and other stakeholders) in safely and securely managing conventional ammunition stockpiles. The UN SaferGuard Programme was simultaneously established as the corresponding knowledge-management platform to oversee and disseminate the IATG.

The IATG also ensure that the United Nations entities consistently deliver high-quality advice and support – from mine action to counter-terrorism, from child protection to disarmament, from crime reduction to development.

The IATG consist of 12 volumes that provide practical guidance for a 'through-life management' approach to ammunition management. The IATG can be applied at the guidelines' **basic, intermediate, or advanced levels**, making the IATG relevant for all situations by taking into account the diversity in capacities and resources available. Interested States and other stakeholders can **utilize the IATG for the development of national standards and standing operating procedures**.

The IATG are reviewed and updated at a minimum of every five years, to reflect evolving ammunition stockpile-management norms and practices, and to incorporate changes due to changing international regulations and requirements. The review is undertaken by the UN SaferGuard Technical Review Board composed of national technical experts with the support of a corresponding Strategic Coordination Group comprised of expert organisations applying the IATG in practice.

The latest version of each IATG module can be found at www.un.org/disarmament/ammunition.

[1] S/2008/258.

[2] See also the urgent need to address poorly-maintained stockpiles as formulated by the United Nations Secretary-General in his Agenda for Disarmament, *Securing Our Common Future* (2018).

Introduction

The storage and handling of ammunition and explosives within an ammunition storage area are operations that present inherent risks to persons and property. A national authority shall therefore have a legal responsibility to ensure, during any operation involving storage and/or handling of ammunition and explosives, that the risks associated with those operations are both tolerable and as low as reasonably practicable (ALARP) .

One of the most efficient means of protecting the public from the effects of an explosive event is by the use of separation distances, which ensure that they are always at a tolerably safe distance from the explosives during storage and handling. A point to remember is the greater the separation distance, the greater the protection afforded.

An assessment of the effects of an undesirable explosives event (e.g. blast, thermal fireball, and fragment and structural debris) radii), and predictions as to which specified levels of risk (in terms of injury or damage) has allowed the development of 'best practice' separation distances. Tables of Net Explosive Quantity (NEQ) and associated minimum, recommended distances have been developed by regional organisations. These tables, (which contain appropriate separation distances), are known as Quantity Distance (QD) Tables and, together with other criteria for their use, should form the foundation for the safe storage and licensing[3] of Potential Explosion Sites (PES) as well as for the placement of any Exposed Sites (ES) in a location where they are not hazarded by explosion effects that could emanate from an explosion at any PES. These QD Tables are based on trials and other data, but are susceptible to uncertainty owing to the variability of the nature of explosions and the incompleteness of trials data.[4] QD should therefore be subject to continuing refinement, as further data becomes available. Such information should be shared internationally.

As an additional precaution, users of the recommended QD contained within this IATG need to understand that the use of QD is by necessity a compromise between 'an acceptable level of risk' and 'absolute protection', as it is generally impractical to procure/restrict all the land around explosives locations such that all risk and explosion effects are eliminated. Glass breakage, some structural damage, and fragment impacts, in some cases capable of injury and possibly death, may be expected to occur outside these 'safe' separation distances. Where available, greater separation than those called for by the minimum QD should be applied whenever possible/practicable.

There is an online IATG Implementation Support Toolkit available on the UN SaferGuard website and among the tools is an Explosives Limits Licence creation tool[5].

[3] See IATG 02.30:2020[E] *Licensing of explosive facilities.*

[4] Even though extensive trials have taken place in support of their development.

[5] www.un.org/disarmament/un-saferguard/explosives-limit-license

Quantity and separation distances

1 Scope

This IATG module introduces and explains the concept and development of quantity and separation distances. It also makes recommendations on the appropriate distances to be used to support the safe, effective and efficient storage and handling of conventional ammunition, and provides an acceptable level of protection to surrounding personnel and ES.

2 Normative references

A list of normative references is given in Annex A. These documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

A further list of informative references is given in Annex B in the form of a bibliography, which lists documents that contain additional information related to the contents of this IATG module.

3 Terms and definitions

For the purposes of this module the following terms and definitions, as well as the more comprehensive list given in IATG 01.40:2020(E) *Glossary of terms, definitions and abbreviations,* shall apply.

The term 'barricade' refers to *a natural ground feature, artificial mound, barricade or wall which, for storage purposes, is capable of preventing direct communication of explosion from one quantity of* ***explosives*** *to another although it may be destroyed in the process*.

A barricade *is capable of intercepting high velocity low angle projections from a potential explosion site and preventing initiation of explosives stocks stored nearby. The term 'traverse' is now been phased out and the alternate 'barricade' is now more frequently used. A barricade might be located at a PES or at an ES. If located at the PES, it may be destroyed by an explosion at that PES, but not until it has achieved its aim.*

The terms 'ammunition storage area', 'explosives area' or 'explosive facility refer to *an area used for the handling, processing and storing of ammunition and explosives. Where there is no fence, it is taken as being the area within a radius of 50m from any building or stack containing ammunition and explosives*.

The term 'exposed site' (ES) refers to *a magazine, cell, stack, truck or trailer loaded with ammunition, ammunition process building (APB), inhabited building, assembly place or public traffic route, which is exposed to the effects of an explosion (or fire) at the potential explosion site (PES) under consideration*.

The term 'heavy walled building' refers to *a building of non-combustible construction used for explosive storage with walls of at least 450 mm reinforced concrete (RC), or 700 mm brick, or equivalent penetration resistance of other materials, with or without a protective roof. The door is normally strengthened if it faces another potential explosion site (PES)*.

The term '*earth-covered magazine (ECM)'*refers to *a magazine, normally built at ground level, with earth-covered roof, sides and rear, and constructed in corrugated steel or reinforced concrete. Formerly called an* 'igloo'*.*

The front wall may/may not be protected by a barricade. When present, a front barricade can provide significant protection to an ECM's contents from an explosion at an adjacent explosive location and potentially mitigate the effects of an explosion inside the ECM.

The term ‘inhabited building’ refers to *a building or structure occupied in whole or in part by people (usually civilian).* The term is used synonymously with *occupied building*.

The term inhabited building distance (IBD) refers to ‘*the minimum permissible distance between potential explosive sites (PES) and non-associated exposed sites (ES) that requires a high degree of protection from an explosion*.

The IBD is a form of Outside Quantity Distance (OQD).

The term ‘inside quantity distance’ (IQD) refers to *the minimum permissible distance between a potential explosion site (PES) and an exposed site (ES) inside the explosives area*.

The term ‘inter-magazine distance’ (IMD) refers to *the minimum permissible distance between a building or stack containing explosives to other such buildings or stacks, which will prevent the immediate propagation of explosions or fire from one to the other by missile, flame or blast*.

The IMD is a form of Inside Quantity Distance (IQD).

Subsequent reactions (fire or detonation) may still occur at adjacent explosive locations that meet IMD, as a result of burning debris, high angle fragment impacts, building collapse, etc.

The term ‘magazine’ refers to *any building, structure, or container approved for the storage of explosive materials. (c.f. explosive storehouse (ESH)*’.

The term ‘marshalling yard’ refers to *groups of railway sidings in which freight trains are formed/reformed, or areas where road convoys are assembled*.

The term ‘outside quantity distance’ (OQD) refers to *the minimum permissible distance between a potential explosion site (PES) and an exposed site (ES) outside the explosives area*.

The term ‘potential explosion site’ (PES) refers to *the location of a quantity of explosives that will create a blast, fragment, thermal or debris hazard in the event of an explosion of its content*.

The term ‘process building distance’ (PBD) refers to *the minimum permissible distance from a building or stack containing explosives to an ammunition process building, or from an ammunition process building to another ammunition process building, which will provide a reasonable degree of immunity for the operatives within the ammunition process building(s), and a high degree of protection against immediate or subsequent propagation of explosions*.
The PBD is a form of Inside Quantity Distance (IQD).

The term ‘public traffic route’ (PTR) refers to *a road used for general public traffic; a railway outside the explosives area that is used for public passenger traffic; a waterway, such as a river having tidal water and a canal, used by passenger vessels*.

A PTR is an ES.

The term ‘public traffic route distance’ (PTRD) refers to *the minimum permissible distance between a potential explosion site (PES) and public traffic routes, which is such that the ignition or explosion of explosives at the PES will not cause intolerable danger to the occupants of vehicles at an exposed site (ES*).

The PTRD is a form of Outside Quantity Distance (OQD).

The term ‘quantity distance’ (QD) refers to *the minimum permissible distance required between a potential explosion site (PES) and an exposed site (ES)*.

The term ‘separation distance’ refers to *a generic term for the minimum permissible distance between a potential explosion site (PES) and an exposed site (ES).*

Separation distances may or may not involve the use of the quantity distance system. They can be developed through the use of an explosion consequence analysis.

The term 'transit area' refers to *areas where consignments of explosives undergoing movements are assembled/dismantled for transhipment between modes of transport that operate within an explosives facility and those that operate outside the area.*

The term 'vulnerable building' refers to *an exposed site (ES) deemed to be vulnerable by nature of its construction or function and therefore sited at greater than normal OQD*.

Examples are multi-story buildings with a large expanse of exposed glass facing the PES, hospitals, places of high concentrations of people such as schools and churches, and warehouse type structures that use curtain-wall construction techniques.

The term 'vulnerable building distance' (VBD) refers to *the minimum permissible distance between a potential explosion site (PES) and a vulnerable building.*

The VBD is a form of Outside Quantity Distance (OQD).

In all modules of the International Ammunition Technical Guidelines, the words 'shall', 'should', 'may' and 'can' are used to express provisions in accordance with their usage in ISO standards.

a) **'shall' indicates a requirement**: It is used to indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

b) **'should' indicates a recommendation**: It is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form, 'should not') a certain possibility or course of action is deprecated but not prohibited.

c) **'may' indicates permission**: It is used to indicate a course of action permissible within the limits of the document.

d) **'can' indicates possibility and capability**: It is used for statements of possibility and capability, whether material, physical or casual.

4 Separation distances

A separation distance is the minimum permissible distance between a potential explosion site (PES) and an exposed site (ES) where the risks due to an explosive event have been determined as tolerable by the appropriate national authority. Separation distances may not necessarily involve the use of the quantity distance system (Clause 5). They can be developed through the use of explosion consequence analysis (see IATG 02.10 *Introduction to risk management principles and processes*). Notwithstanding, the use of the quantity distance system is considered to be 'best practice' by many States and will therefore form the basis of the guidance within this IATG module.

Quantity distances do not, however, exclude the risk to the public from projections, broken glass, displaced tiles etc., or the risk of some minor injury to occupants. Glazing is an important factor in building occupant protection and protective features are relatively easy to provide.[6]

5 Background to quantity distances

Many States use rules based upon the explosives, their quantity, and the distance from the explosive to where people and, in some cases, critical facilities/equipment are at risk. These rules are known as Quantity-Distance (Q-D) criteria and are based on the approach derived from the *Hopkinson-*

[6] Analysis of glazing hazards is a specialist component of an explosion consequence analysis. See IATG 02.10 *Introduction to risk management principles and processes* and the *UK Glazing Hazard Guide 1997.*

Cranz Scaling Law,[7] [8] which is further amended by a range of coefficients. It is the basis of much of the work on the estimation of appropriate quantity and separation distances.

The *Hopkinson-Cranz Scaling Law* is also referred to as the *Cube Root Scaling Law*:

$(R_1/R_2) = (W_1/W_2)^{1/3}$ $R = ZW^{1/3}$	R = Range (m) Z = Constant of Proportionality (dependent on acceptable blast overpressure). **The coefficient 'Q' is used for QD work.** W = Explosive Weight (kg) **The coefficient NEQ is used for QD work.**

Table 1: Hopkinson-Cranz Scaling Law

Examples of the coefficient 'Q' used in explosive storage safety[9] for above ground storage are shown in Table 2, which are based on regional[10] 'best practice':

Q	QD	Purpose	Remarks
3,6 (IMD) **8.0 (PBD)**	Inside Quantity Distance (IQD)	Used to predict minimum separation distances that should be observed between PES and ES that contain explosives (which are in effect also PES), and between PES and ammunition process buildings (APB). .	▪ Minimum permissible distances further apply if R is below a certain level, which differs for each 'Z' function.
14.8	Public Traffic Route Distance (PTRD)	Used to predict minimum separation distances between a PES and a public traffic route with civilian access.	
22.2	Inhabited Building Distance (IBD)	Used to predict minimum separation distances between a PES and a building inhabited by civilians.	
44.4	Vulnerable Building Distance (VBD)	Used to predict minimum separation distances between a PES and a vulnerable building.	

Table 2: Examples of Coefficient 'Q'

The particular QD coefficients 'Q' shown at Table 2 are based on trials and other data, but are susceptible to uncertainty owing to the variability of the nature of explosions and the incompleteness of the trials data. Because of this, QD should be subject to continuing refinement, as further data becomes available.

The use of QD requires compliance with the UN explosive classification system as all of the available previous work in the area of QD has used the UN system of hazard divisions.[11]

A less complex system of the use of QD is that of the former Warsaw Pact that utilised the QD shown in Table 3.

[7] Hopkinson B, UK Ordnance Board Minutes 13565, 1915.

[8] Cranz C, *Lehrbuch der Ballistik*, Springer-Verlag, Berlin, 1916.

[9] These are the default 'Q' settings in the IATG Software, although the software does allow the user to input alternative 'Q' values.

[10] OSCE and NATO regions.

[11] See IATG 01.50: *UN explosive classification system and codes.*

Q	QD	Purpose	Comment
4.5	Human Defeat Distance (Blast)	Used to predict separation distances for blast effects from a PES to individuals.	
14.0	Human Defeat Distance (Fragmentation)	Used to predict separation distances for fragmentation effects from a PES to individuals.	Similar to the Public Traffic Route Distance (PTRD) at Table 2.

Table 3: Examples of Coefficient 'Q'

6 Types of quantity distances

There are two major types of quantity distance, the inside quantity distance (IQD) and the outside quantity distance (OQD). These in turn have sub-types, summarised at Table 4.

QD Type	Applicability	QD Sub-Types
Inside Quantity Distance (IQD)	Only usually inside the designated explosives area.	(Ammunition) Process Building Distance (PBD)
		Inter-Magazine Distance (IMD)
Outside Quantity Distances (OQD)	Only outside the designated explosives area[12].	Public Traffic Route Distance (PTRD)
		Inhabited Building Distance (IBD)
		Vulnerable Building Distance (VBD)

Table 4: Types of QD

6.1 Inside quantity distances (IQD) (LEVEL 1)

IQD are the minimum distances that should be observed between PES and ES that contain explosives (which are in effect also PES), and between PES and ammunition process buildings (APB).

6.1.1. Process building distances (PBD)

PBD provide a high degree of protection against immediate or subsequent propagation of an explosion in the APB. PBD are generally intended for situations where personnel are regularly employed in the preparation or processing of explosives.

PBD are the minimum distances that should be observed either between PES and APBs, or between APBs. They are intended to give a reasonable degree of immunity to personnel within a hardened and barricaded APB from the effects of a nearby explosion. Light structured APBs are likely to be damaged if not completely destroyed, and as such offer minimal protection to personnel inside them.

6.1.2. Inter-magazine distances (IMD)

IMD are the minimum distances to be observed between individual PES and ES that contain explosives (which are in effect also PES) and are designed to provide specified degrees of protection

[12] See Clause 3 *Terms and definitions and* IATG 01.40 Glossary of *terms, definitions and appreciations*: **Explosives area** means an area used for the handling, processing and storing of ammunition and explosives. Where there is no fence, it is taken as being the area within a radius of 50m from any building or stack containing explosives.

to explosives at an ES. Primarily, these distances are intended to prevent direct propagation at each ES for each Hazard Division (HD). An explosion at a PES may lead indirectly to explosions at a nearby PES due to secondary fires, but this situation is more likely at the lowest degree of protection, detailed below.

6.2 Outside quantity distances (OQD) (LEVEL 1)

OQD are minimum distances to be observed between PES and non-explosives area related ES such as public roads, railways, civil airport facilities, inhabited buildings and other buildings/areas, whether they be inside or outside the explosives area, which are used by the general public and/or government personnel. In certain circumstances, such as when there is low density traffic on a road, minimum fragment distances are applied.

6.2.1. Public traffic route distance (PTRD)

PTRD should be the distances to be observed between PES and routes used by the general public, which are generically referred to as Public Traffic Routes. These include:

a) roads;

b) railways;

c) waterways, including rivers, canals and lakes;

d) runways, taxi ways and aircraft parking areas ; and

e) public rights of way (e.g. footpaths).

The distance required is based on the amount of usage of the route by vehicles, people, etc., also known as traffic density. Examples of usage rates for each density level that should be considered are shown in the footnotes at Annex D. Three alternative QD should therefore be used, dependent on the average public usage of the route, as shown in Table 5:

Density	Criteria (per day)	Appropriate QD
High Density Usage	Roads - 5000 or more vehicles Railways - 5000 or more rail passengers Waterways – 1800 or more users Public Rights of Way or Recreational Facilities – 900 or more users	100% of IBD
Medium Density Usage (the PTRD)	Roads - 1000 or more but less than 5000 vehicles Railways – 1000 or more but less than 5000 passengers Waterways – 400 or more but less than 1800 users Public Rights of Way or Recreational Facilities – 200 or more but less than 900 users	67% of IBD
Low Density Usage	Roads - Less than 1000 vehicles Railways – Less than 1000 passengers Waterways – Less than 400 users Public Rights of Way or Recreational Facilities – Less than 200 users	50% of IBD

Table 5: Types of QD for PTR

The numbers of people exposed to the hazard and their relative times of exposure should be determined by the average of the traffic or people counted, as appropriate, over a number of 24 hour periods.

Similar QD to those suggested for public rights of way should be applied to playing fields, golf courses and similar recreational facilities. These should be subject to the same minimum QD requirements.

6.2.2. Inhabited building distance (IBD)

IBD should be the minimum distances to be observed between PES and buildings or sites where members of the general public, or personnel not involved in explosives-related operations, either work, live or congregate. Planners should be aware that some public gathering sites, such as periodic, seasonal, or itinerant markets, may not exist on a permanent or daily basis.

The distances are intended to prevent serious structural damage to traditional types of inhabited buildings or caravans, and any consequential death or serious injury to their occupants. Persons in the open would not suffer direct injury from the effects of blast and radiant heat at these distances.

Fragments and debris may cause some injuries. The extent of injuries will depend upon the PES structure and the NEQ and fragmentation characteristics of the ammunition and explosives involved. At this distance, the fragment threat is defined as one hazardous fragment of 80 joules/56m^2. The fragment threat will decrease as the distance from the PES increases. The distances do not, however, exclude the risk to the public from projections falling from structures, broken glass, displaced tiles etc., or the risk of some minor injury to occupants. Glazing is an important factor in building occupant protection and protective features are relatively easy to provide.

IBD are normally subject to fixed minimum distances to give protection against fragments and debris emanating from a PES.

6.2.3. Vulnerable building distance (VBD)

Where an inhabited building is of vulnerable construction (e.g. glass facade) or is a large facility of special importance (e.g. a school), larger distances (normally 44.4Q$^{1/3}$) shall be applied from PES containing HD 1.1 to afford a higher degree of protection. Examples are given in the quantity distance matrices that follow.

7 Rules for use of quantity distances (above ground storage)[13] (LEVEL 1)

7.1 Guidance

In order that the QD system is most effectively implemented users should comply fully with the requirements of this clause.

7.2 Measurement of distances

QD shall be accurately measured from the nearest point of the PES, or hard-standing of an open stack PES, to the nearest point of the ES or hard-standing of an open stack ES. Distances are measured along a straight line without regard for barricades or earth cover.

7.3 Unitisation

Where the total Net Explosive Quantity (NEQ) in a PES (including an ammunition process building (APB)) is separated into stacks such that the maximum credible event is limited to the quantity in any one stack (referred to as unit risk or unitisation), distances may be measured from the outside of the wall adjacent to the controlling stack concerned to the nearest outside wall of the ES. If the separation to prevent practically instantaneous propagation is provided by one or more substantial dividing walls within a PES, then the QD may be measured from these walls instead of from the

[13] More specific rules for underground storage, storage in ports and transit areas follow later in this IATG. These rules at Clause 7 shall also apply, where appropriate and unless superseded by guidance that follows later.

outside walls. Details on the construction of these types of walls, which are rarely used, may be found in UFC 3-340-02 (see Annex B).

The use of unitisation may also allow for reduced QD to be applied. Specialist ammunition technical advice should be obtained in these circumstances as it is a highly complex issue. Similar advice should also be sought should purpose built compartmentalised buildings be available for ammunition and explosive storage.

7.4 Intervening structures

In general, because of its very complicated nature, the effect of intervening buildings and structures, other than barricades, should be ignored when applying QD. In an exceptional case, such as a high building that has the same effect as a barricade, the situation should be specially assessed by qualified technical staff.

7.5 Net Explosive Quantity (NEQ)

Unless it has been determined by trials that the effective NEQ is significantly different from the actual NEQ, the total NEQ of explosives in a single PES should be used for the computation of QD. When HDs have to be mixed in a storage location then the aggregation rules at Table 6 shall apply.[14] HD 1.4, 1.5, and 1.6 are addressed in 10.2 below.

Serial	Hazard Divisions			Storage Requirement
	1.1	1.2	1.3	
1	YES	NO	NO	▪ Use HD 1.1 Quantity Distance.
2	YES	YES	NO	▪ Aggregate the HD 1.1 and 1.2 NEQ. ▪ Evaluate aggregate as HD 1.1 then as HD 1.2 and use the greater Quantity Distance.
3	YES	YES	YES	▪ Aggregate the HD 1.1, 1.2 and 1.3 NEQ. ▪ Evaluate aggregate as HD 1.1 then as HD 1.2 and use the greater Quantity Distance.
4	YES	NO	YES	▪ Aggregate the HD 1.1 and 1.3 NEQ. ▪ Use HD 1.1 Quantity Distance for the aggregated NEQ total.
5	NO	YES	NO	▪ Use HD 1.2 Quantity Distance.
6	NO	YES	YES	▪ Assess QD for the NEQ of each HD. ▪ Use the greatest Quantity Distance.
7	NO	NO	YES	▪ Use HD 1.3 Quantity Distance.

Table 6: Aggregation rules

The NEQ does not include substances such as white phosphorus, chemical agents, smoke, or incendiary compositions unless these substances contribute significantly to the dominant HD concerned. Any other energetic materials such as liquid fuels should be aggregated with the explosive NEQ unless it has been determined by testing that they do not contribute to the overall hazard.

7.6 Determination of quantity distances or permissible quantities

The location of PES with respect to each other and to other ES is based on the total NEQ in the individual PES unless this total NEQ is subdivided such that an incident involving any one of the smaller concentrations cannot produce a practically instantaneous explosion in adjacent stacks.

[14] This includes individual storage locations.

The QD required between each of two or more nearby storage sites or ammunition process buildings that contain explosives of one HD only are determined by considering each as a PES. The NEQ permitted in the storage sites or ammunition process buildings is limited to the least amount allowed by the appropriate table for the distances separating the storage sites or ammunition process buildings concerned. The QD required from each of two or more nearby storage sites to contain given quantities of explosives of different HDs at different times should be determined as follows:

a) consider each building or stack, in turn, as a PES;

b) refer to the table of each HD that can be stored in the building or stack considered as a PES;

c) determine the QD for each HD as the minimum to be required from the building or stack; and

d) record the QD in terms of each HD in each instance as those to be required from the building or stack. Alternatively, calculate the permitted NEQ of each HD based upon the available distances.

7.7 Rounding of quantity distance

The values of QD in the QD Tables that follow have been rounded up in accordance with Table 7, below. It is permitted to determine a QD using the distance function formulae at the foot of the appropriate column in the QD Table. A calculated distance, rounded up to the nearest metre, may be used in place of any value in the QD Tables. If an NEQ is back calculated from a distance, using the appropriate QD formula, the answer should be rounded down to the nearest kg.

Range of Value of QD (kg)	Rounded to the Nearest (m)
2 to <100	1
>100 to <500	5
>500 to <1,000	10
> 1,000	20

Table 7: Rounding of QD

8 Rationale for selected quantity distances

The rationale for the QD coefficients selected and used in the QD Tables within this IATG is based on trials, experimentation, modelling and analysis of real explosive events.[15] The primary threat to structures is blast impulse energy, which is a function of overpressure and event duration. For a small NEQ, with little duration, the threat to structures is significantly less than from a very large NEQ event (in the thousands of kg), which would have a very long duration, and consequently a very high impulse. The QD factors were initially developed for these very large NEQ events and then scaled down to apply for smaller quantities. Therefore, for the storage of smaller NEQ quantities the use the explosion consequence analysis (ECA) methodology may be more appropriate (see IATG 02.10 *Introduction to risk management principles and processes*).[16] The expected effects, and impact on facilities and personnel, over a range of QD coefficients for explosives have been estimated for Hazard Division 1.1. These are summarised in Table 8 for above ground storage, and will differ for explosives in HD 1.2 and 1.3 (see later):

[15] Conducted by NATO Nations for the development of NATO AASTPs.

[16] NATO AASTP-1 does not contain criteria for HD 1.1 NEQ < 500kg. Consequently, the criteria contained in Annexes D and E for HD 1.1 NEQ $\leq$ 50kg and for HD 1.1 NEQ > 50kg has therefore been extrapolated (as a temporary measure) from Tables V3.E3.T1 and V3.E3.T3 of US DoDM 6055.09, *Ammunition and Explosives Safety Standards* and NATO AASTP-1. Until NATO has further developed AASTP-1 to include QD for < 500kg, these particular recommended QD should be used with **extreme caution**. The NATO developed criteria is expected in 2021, and this IATG will then be further amended as necessary once NATO has released the data.

QD[17]	QD Type / Examples	Effects and Impact	
		Structures	**Personnel**
$D_Q = 44.4Q^{1/3}$	Vulnerable Building Distance (VBD) (Purple Line) ▪ Hospitals. ▪ Schools. ▪ Multi-story offices. ▪ Apartments. ▪ Oil Refineries.	▪ Un-strengthened normal structures are likely to suffer only superficial damage. ▪ Certain types of vulnerable structures may collapse and cause injuries or death by crushing and falling debris. ▪ When large panes of glass or other non-load bearing frangible materials, e.g. external cladding panels, are exposed so as to face a PES, 50% or more of these may be detached from the structure or broken by the blast.	▪ Injuries and fatalities are very unlikely as a direct result of blast effects. ▪ Injuries that do occur will be caused principally by the impact on passers-by of falling, broken or detached panel or window materials. ▪ The risk of injury will often be reduced by minimising personnel exposure by, for example, placing gardens around the foot of buildings. ▪ Peak side-on overpressure is 2.0 – 3.0 KPa.
$D_Q = 22.2Q^{1/3}$	Inhabited Building Distance (IBD) (Yellow Line) ▪ Civilian houses. ▪ Major military admin area. ▪ Major road and rail routes.	▪ Un-strengthened buildings will suffer minor damage, particularly to parts such as windows, door frames and chimneys. ▪ Partial collapse may occur in buildings where structural integrity relies either on critical elements or the continuity of the structure.	▪ Injuries and fatalities are very unlikely as a direct result of the blast effects. ▪ Injuries that do occur will be caused principally by glass breakage and flying/falling debris. ▪ Peak side-on overpressure is 5KPa.
$D_Q = 14.8Q^{1/3}$	Public Traffic Route Distance (PTRD) (Green Line) ▪ Medium or minor roads and rail routes. ▪ Sports fields. ▪ Minimum distance at which public may be placed at risk ▪ Administrative buildings related to the explosives activity with < 20 people	▪ Un-strengthened buildings will suffer average damage costing in the range of 10% of total replacement cost to repair.	▪ Personnel under cover are afforded a high degree of protection from death or serious injury. ▪ Such injuries as do occur will be mainly caused by glass breakage and building debris. ▪ Personnel in the open are not likely to be seriously injured by blast but some injuries are likely to be caused by fragments and debris depending on the structure of the PES, the NEQ involved and fragmentation characteristics. ▪ Peak side-on overpressure is 9KPa.
$D_Q = 11.1Q^{1/3}$	▪ (Blue Line) Low density roads, railways and public rights of way.	This is the acceptable level of protection for low-density areas. ▪ Un-strengthened buildings will suffer average damage up to 20% of replacement cost.	▪ Personnel in the open are not likely to suffer any injuries from blast or any significant injuries from debris. ▪ Peak side-on overpressure is 11KPa.

[17] Where D_Q = Distance (m), and Q = NEQ (kg)

QD[17]	QD Type / Examples	Effects and Impact	
		Structures	**Personnel**
$D_Q = 9.6Q^{1/3}$	Military at Risk ▪ Military sports fields. ▪ Military training areas. ▪ Military aircraft.	▪ Buildings that are un-strengthened 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 prohibitively expensive. ▪ Cars may suffer some damage to metal portions of the roof and body by blast. Windows may be broken; however, the glass should not cause serious injury to the occupants. ▪ Aircraft will suffer some damage to appendages and sheet metal skin. ▪ Cargo type ships will suffer minor damage from blast to deck houses and electronic gear.	▪ Personnel may suffer temporary hearing loss; however, permanent ear damage is not likely. There are likely to be some injuries caused by fragments, debris, or translation of the individual(s) involved. ▪ Peak side-on overpressure is 16KPa.
$D_Q = 8.0Q^{1/3}$	(Ammunition) Process Building Distance (PBD) ▪ Ammunition process buildings (APB). ▪ Minor communication links.	▪ Buildings, which are un-strengthened, can be expected to suffer damage that is likely to cost above 30% of the total replacement cost to repair. ▪ 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. ▪ Cargo ships will suffer damage to decks and superstructure. In particular, doors and bulkheads on the weather deck are likely to be buckled by the overpressure. ▪ Aircraft are expected to sustain considerable structural damage.	▪ Serious injuries to personnel, which may result in death, are likely to occur due to fragments, debris, firebrands or other objects. ▪ Peak side-on overpressure is 21 KPa.
$D_Q = 3.6Q^{1/3}$	Inter-Magazine Distances (IMD) ▪ Explosive storehouses (ESH).	▪ Un-strengthened buildings will suffer structural damage approaching total demolition. ▪ Aircraft will be damaged, by both blast and fragments, to the extent that they will be beyond economical repair. ▪ If aircraft are loaded with explosives, delayed explosions are likely to result from subsequent fires. ▪ A high degree of protection against direct propagation of an explosion is to be expected, provided direct attack by high velocity fragments is prevented, e.g. by a receptor barricade. ▪ Explosions may subsequently occur in adjacent PES from fire spread by lobbed debris or blast damage to an ES.	▪ Severe injuries or death to occupants of the ES are to be expected from direct blast, fragment impact, building collapse, or translation. ▪ Peak side-on overpressure is 70KPa. ▪ At 105 KPa there is a 50% chance personnel will suffer ear drum damage. ▪ At 130 KPa there is a 50% chance of death due to lung damage.

QD[17]	QD Type / Examples	Effects and Impact	
		Structures	Personnel
$D_Q = 2.4Q^{1/3}$	Inter-Magazine Distances (IMD) ▪ ESH (ECM).	▪ Un-strengthened buildings will suffer complete demolition.	▪ Severe injuries or death to occupants of the ES are to be expected from direct blast, fragment blast, building collapse, or translation. ▪ Peak side-on overpressure is 180KPa.

Table 8: Effects and impact of QD for HD 1.1

There are a range of factors that are used to determine the QD for a particular HD from a PES, which are:

a) the NEQ at the PES and the type, sensitiveness and packaging of the explosives at the ES;

b) the type, use, method of construction and orientation of both the PES and the ES;

c) the presence of effective barricades ;

d) the degree of protection required at the PES and ES;

e) the adequacy of evacuation arrangements for ammunition depot staff and the local population; and

f) the HD Storage sub-Division (SsD). Storage sub-divisions (SsD) are explained below in table 9 and at IATG 5.20 Types of Buildings for Explosives Storage (articles 5.2 and 5.3).

The provision of stronger and more robust ESH allows for the use of smaller QD for a given degree of protection or achieves a higher standard of protection at a given distance, especially in the case of an ES near a PES containing explosives of HD 1.1. Yet some stronger and more robust ESH may also increase OQDs as their heavier structure can produce large, long-range fragments in the event of an explosion within.

9 Symbols

For above ground storage a range of standard symbols should be used to represent the various types of PES and ES during the use of QD methodology. Annex C contains the common symbols that are used within this IATG and the supporting IATG software.

10 Hazard division quantity distance matrices (LEVEL 1)

10.1 HD 1.1, HD 1.2 and HD 1.3

Quantity distance matrices, which contain the appropriate QD factor that should be used between differing PES and ES, are at the Annexes shown in Table 9:

Hazard Division (SsD)	Definition	Annex
Above ground storage		
1.1	Ammunition that has a mass explosion hazard.	▪ Annex D
1.2.1	Ammunition that has a projection hazard but not a mass explosion hazard. (More hazardous items of HD 1.2, which give large fragments over an extended range). HD 1.2 items with HE NEQ of above 0.136kg.	▪ Annex F
1.2.2	Ammunition that has a projection hazard but not a mass explosion hazard. (The less hazardous items of HD 1.2, which give smaller fragments of limited range). HD 1.2 items with HE NEQ of equal to or below 0.136kg.	▪ Annex G

Hazard Division (SsD)	Definition	Annex
1.2.3	Ammunition that exhibit at most an explosion reaction during sympathetic reaction testing and a burning reaction in bullet impact or heating tests. (This is a 'new' SsD and is derived from NATO AASTP-3, Edition 1, Change 3. *Manual of NATO Safety Principles for the Hazard Classification of Military Ammunition and Explosives.* August 2009).	▪ Not yet available
1.3.1	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard. (The more hazardous items with mass fire hazard and considerable thermal radiation).	▪ Annex J
1.3.2	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard. (The less hazardous items that burn sporadically).	▪ Annex K
Underground storage		
1.1	Ammunition that has a mass explosion hazard.	▪ Annex M
1.2	Ammunition that has a projection hazard but not a mass explosion hazard.	▪ Annex M
1.3	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard. (This is treated as if it is HD 1.1 because of the overall degree of confinement in underground storage).	▪ Annex M
Ports		
1.1	Ammunition that has a mass explosion hazard.	▪ Annex P
1.2	Ammunition that has a projection hazard but not a mass explosion hazard.	▪ Annex P
1.3	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.	▪ Annex P

Table 9: QD matrices by Annex

The matrices contain a 'D' reference, which refers to the QD column in the HD QD tables (see Clause 11).

For inter-magazine distances (IMD) the matrix also indicates the level of protection afforded to the ammunition stocks at the ES should there be an explosive event within a PES containing HD 1.1 or HD 1.2 ammunition. This level of protection is indicated in Table 10:

Protection Level	Explanation
Virtually complete protection (1.1)	▪ Gives virtually complete protection against practically instantaneous propagation of an explosion by ground shock, blast, flame and high velocity projections. ▪ There are unlikely to be fires or subsequent explosions caused by these effects or by lobbed munitions. ▪ The stocks are likely to remain serviceable; however, ground shock may cause indirect damage and even explosions among especially vulnerable types of explosives, or in conditions of saturated soil. ▪ This level of protection is primarily used when both the PES and the ES are earth-covered structures.
Virtually complete protection (1.2)	▪ Gives virtually complete protection against all explosion effects from the PES. ▪ Ammunition and explosives will remain serviceable at ES.

Protection Level	Explanation
High degree of protection (1.1)	▪ Gives a high degree of protection against practically instantaneous propagation of an explosion by ground shock, blast, flame and high velocity projections. ▪ There may be occasional fires or subsequent explosions caused by these effects or by lobbed munitions. ▪ Heavy cased items (e.g. aircraft bombs and robust shell) are likely to remain serviceable although they may be covered by building or barricade debris. ▪ However, there is a significant increase in the probability that other stocks of explosives will be lost through subsequent propagation from lobbed explosive items or the spread of burning debris. This is particularly so where flammable material, such as wooden packages or dunnage, is present at the ES.
High degree of protection (1.2)	• Gives a high degree of protection against most explosion effects from the PES. • Ammunition and explosives are likely to remain serviceable.
Limited degree of protection (1.1)	• Gives only a limited degree of protection against practically instantaneous propagation of an explosion by ground shock, blast, flame and high velocity projections. • There are likely to be fires or subsequent explosions caused by these effects or by lobbed munitions. • Heavy cased munitions are likely to be damaged and rendered unserviceable and are likely to be completely buried by debris. • There is a high probability that stocks of explosives will be lost through subsequent propagation from lobbed munitions or the spread of burning debris. This is particularly so where flammable materials, such as wooden packages or dunnage, are present at the ES.
Limited degree of protection (1.2)	• Gives limited degree of protection against some explosion effects from the PES. • Ammunition and explosives are unlikely to remain serviceable.

Table 10: Protection levels from IMD

10.2 HD 1.4, HD 1.5 and HD 1.6

Distances from a PES containing ammunition and explosives of HD 1.4 are not a function of NEQ. Separation distances should be based on the fire risks and fire-fighting capability available. The separation distance for a PES of open stacks or light buildings to any type of ES should be greater than 10m. For more robust buildings the separation distance should be that required for emergency access.

Ammunition and explosives of HD 1.5 contain insensitive explosive substances, which are so insensitive that there is very little likelihood of initiation or transition from burning to detonation when stored in isolation. Nevertheless, in order to allow for storage flexibility, they should be considered to be HD 1.1 for the purposes of QD estimation.

Ammunition of HD 1.6 contains extremely insensitive substances. National efforts to develop HD 1.6 munitions began in the 1970s, and due to the difficulty in developing such munitions, this effort is still ongoing. Detailed storage advice may be found in the NATO publication AASTP-1, whilst UN Test Series 7 will determine if ammunition and explosives may be classified as HD 1.6.

11 Hazard division quantity distance tables (LEVEL 1)

Quantity distance tables, which contain the appropriate QD, (pre-calculated for a range of NEQ and minimum permissible distances), that should be used between differing PES and ES, are at the Annexes shown in Table 11:

Hazard Division	Definition	Annex
Above ground storage		
1.1	Ammunition that has a mass explosion hazard.	▪ Annex E
1.2	Ammunition that has a projection hazard but not a mass explosion hazard.	▪ Annex H
1.3	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.	▪ Annex L
Underground storage		
1.1	Ammunition that has a mass explosion hazard.	▪ Annexes N and M ▪ Also see Clause 13.
1.2	Ammunition that has a projection hazard but not a mass explosion hazard.	
1.3	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.	
Ports		
1.1	Ammunition that has a mass explosion hazard.	▪ Annex Q ▪ Also see Clause 14.
1.2	Ammunition that has a projection hazard but not a mass explosion hazard.	
1.3	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.	

Table 11: QD Tables by Annex

12 Marshalling yards and transit areas (LEVEL 2)

Quantity distances for marshalling yards and transit areas should be applied as shown in Table 12:

Type		QD
Class	**Definition**	
A	Facility is used for **more than** One Day per Week. OR Facility is used for HD 1.1	▪ The appropriate IBD shall be used.
B	Facility is used for **less than** One Day per Week No HD 1.1 is moved through the facility.	▪ The appropriate PTRD is to be used.

Table 12: QD for marshalling areas and transit areas

13 Underground storage (LEVEL 2)

13.1 General

The development of appropriate quantity distances for underground storage is much more complex than for above ground storage as more technical factors (geology, channelling of blast, impact of ground shock, etc.) must be considered. Unlike above ground storage, the effects of an undesirable explosion are not omni-directional in their effects on the general public and property.

QD for this type of storage should be developed by appropriately qualified personnel in accordance with NATO AASTP-1 Part 3 *Underground explosives storage*. Aspects of the NATO publication, which is international best practice, are included in this IATG for information and basic guidance only. This information should only be used as a basic staff check to gain an overview of the safety aspects of current underground storage within a State in order to identify if current QD are appropriate.

Information on the design of underground storage facilities may be found in NATO AASTP-1 Part 3 *Underground explosives storage*.

There are two types of underground storage:

a) chambers. These are specially constructed within the rock, and are connected to the outside, and to each other, by tunnels; and

b) natural rock caverns. These are occasionally used, but as the geology, size and shape all impact on their performance in terms of explosion mitigation they are not covered further in this IATG. Each location should be assessed by an explosion consequence analysis developed by an appropriate qualified specialist before explosive limits can be determined.

13.2 Effects from underground explosions

13.2.1. Confinement

Underground storage usually means that the level of confinement in the event of an explosion is much greater than for above ground storage. The volumetric loading density (kg/m^3) within the underground storage therefore introduces a new factor when determining appropriate quantity distances.

13.2.2. Blast

An explosion underground will result in a directional blast wave that will sweep through all tunnels and chambers connected to the initial chamber. The initial pressure will increase with the explosive volumetric loading density within the chamber, being proportional to the cube root of the loading density. Where a tunnel reaches the surface, the underground blast wave will give rise to a blast wave in the air broadly similar to that of a surface explosion, although strong directional effects can be expected. There is also a possibility of propagation by hot gases or flame, which could flow from pre-existing crevices between the chambers. Quasi-static action of the explosion gases may also open up incipient cracks and crevices extending between the two chambers, providing a potential route for propagation of the explosion by the hot gases. The prediction of explosion effects in underground storage is more complex than for above ground storage and should be supported by modelling. Blast effects should be predicted from tunnel adits and from surface craters if rock cover is insufficient.

13.3 Ground shock

The high gas pressure from an explosion will be transferred to the chamber floor, walls and roof, resulting in a ground shock wave. The shock wave velocity will be greater than a shock wave in air due to the higher density of the rock.

Spalling of the rock face or walls of another nearby chamber, possibly causing a reaction in any explosives present there, may also result.

It is possible that ground shock and the sustained high pressure within the initial chamber may, depending on the cover thickness, cause a breach of the rock/earth cover of the chamber. This may cause ejection of the rock, etc., forming the cover, and release of the high-pressure gases from the chamber. This will give rise to an additional blast wave in the air, similar to that from a surface explosion.

Table M.1 provides equations for estimations of ground shock effects suitable for a basic staff check. More detailed calculations should be used when planning new storage or if the basic staff check suggests that current separation distances are unsuitable (see NATO AASTP-1 Part 3 *Underground explosives storage*, Clause 3.3.4.3).

13.4 Fragments and debris

Primary fragments and debris will be carried along all tunnels connected to the chamber by the blast flow; they will also be projected in a relatively narrow angle directly away from the tunnel entrance. Some debris will be projected to great distances along the centre line away from the tunnel entrance in a manner similar to the projection of a shell from a gun barrel. Earth barricades or robust head walls should be used to 'catch' this fragmentation, the advantage being a significantly reduced QD emanating from the tunnel opening.

Within the tunnel complex, changes of tunnel direction can be designed to provide 'debris traps' that will trap debris that cannot follow the blast wave around the change of direction. Multiple 'debris traps' will eventually significantly reduce the threat (and IBD) resulting from fragments and debris when the blast wave reaches the tunnel entrance.

13.5 Types of quantity distances (underground storage)

The OQD and IQD for underground storage are slightly different than those for above ground storage. They are summarised at Table 13.

QD Type	QD Sub-Types	Applicability
Inside Quantity Distance (IQD)	Ammunition Process Building Distance (APBD)	Distance to APB inside the underground system. This may also be referred to as the Explosives Workshop Distance (EWD).
	Chamber Interval (CID)	Distance between underground storage chambers.
Outside Quantity Distances (OQD)	Above Ground Magazine Distance (AGMD)	Distance to a non-ECM type ESH outside the underground system.
	Earth Covered Magazine Distance (ECMD)	Distance to an ECM type ESH outside the underground system.
	Ammunition Process Building Distance (APBD)	Distance to APB outside the underground system. This may also be referred to as the Explosives Workshop Distance (EWD).
	Public Traffic Route Distance (PTRD)	Distance from underground storage to routes and buildings outside the explosives area.
	Inhabited Building Distance (IBD)	
	Vulnerable Building Distance (VBD)	

Table 13: Types of QD (underground storage)

13.6 Applicability of quantity distances (underground storage)

Explosives of HD 1.2 are expected to respond underground in an intermittent manner without causing a mass explosion with its significant blast and ground shock effects. Quantity distances should therefore not be applied to explosives of HD 1.2.

Explosives of HD 1.4 stored underground do not require quantity distances.

Explosives of HD 1.5 stored underground should be considered to be as if they are in HD 1.1.

Therefore, only explosives of HD 1.1 and HD 1.3 require quantity distances for underground storage. It is important that mixing rules are adjusted to consider explosives of HD 1.3 as HD 1.1 when stored underground.[18]

13.7 Measuring quantity distances (underground storage)

13.7.1. Inside quantity distances

The chamber interval distance (CID) shall be the shortest distance between the natural walls of two adjacent chambers. Any chamber linings shall be ignored.

13.7.2. Outside quantity distances

For blast and debris effects from the tunnel entrance (adit), the OQD shall be measured from the centre of the tunnel entrance to the nearest point of the ES. An extended centre line along the length of the tunnel shall be used as a reference line for any directional effects. Properly constructed barricades will stop fragments and debris coming out the tunnel, thereby providing a significant reduction in fragment-related IBD.

For blast and debris effects from any surface crater formation the OQD shall be measured from the nearest wall of the chamber to the nearest point of the ES, taking account of relevant levels.

13.8 Determining quantity distances (underground storage)

The methodology for determining quantity distances for underground storage is different to that used for above ground storage due to the more unusual effects. Each of the following should be considered, in any order, before a final QD is established, which will be the greatest distance identified:

a) blast effects within underground storage;

b) blast effects from tunnel entrance (adit);

c) blast effects from any surface crater formed;

d) ground shock effects;

e) flame and hot gases;

f) debris effects from tunnel entrance; and

g) debris effects from any surface crater formed.

Underground storage sites that are connected to each other by tunnels should be considered as one single storage site unless adequate precautions are taken to prevent the propagation of an explosion from one chamber to another. Technical judgement should be used.

Table 14 provides guidance on the appropriate QD tables or methodology to be used. The number of variables involved means that QD table guidance cannot be provided for ground shock effects or blast effects from the tunnel entrance. These should be determined using the explosion consequence analysis (ECA) methodology at IATG 02.10 *Introduction to risk management principles and processes*, supported by the information at Annexes M and N:

Effects	IQD		OQD	
	CID	APBD	IBD	PTRD
Blast effects within underground storage	Annex M Table N.1			

[18] Mixing rules are contained in IATG 01.50 *UN explosive classification system and codes,* Clause 7.1.

Effects	IQD		OQD	
	CID	APBD	IBD	PTRD
Blast effects from tunnel entrance		ECA	ECA	ECA
Blast effects from surface crater		Annex M		
Ground shock effects (simple estimation)	Annex M	Annex M	Annex M	Annex M
Debris effects from tunnel entrance		ECA	ECA	ECA
Debris effects from surface crater		Annex M Using Table N.2 or Table N.3		

Table 14: Guidance on Tables for QD estimation (underground storage)

14 Ports (LEVEL 2)

14.1 General

The guidelines that follow should be applied for cargo vessels, whether military or commercial, transporting or storing explosives whilst anchored, moored or berthed within a port. They are not designed to cover the normal ammunition and explosive loads for warships, which are a national responsibility.

An explosive event on a vessel afloat will result in some different effects from an explosive event on land. Explosives stored below the waterline of the vessel, for example, will have some of their explosive effects (e.g. blast, thermal output, etc.) attenuated by water, whilst others will be increased (e.g. ground shock).

14.2 Aggregation of NEQ

The close proximity of ships' compartments and the potential closeness to a shore transfer area means that it is possible that an accidental explosion could involve all of the ship's cargo of explosives. Therefore the whole cargo, whether on the vessel or in the process of transfer, shall be aggregated in accordance with Clause 7.5, Table 6.

It may be possible to arrange for an explosive cargo to be stored on a vessel in such a way that the risk of propagation of an explosion from one stowage location to another is reduced and/or mitigated. In this case the separation distance and traversing shall be robust enough to intercept high velocity fragments to prevent them from initiating a simultaneous explosion. Guidance on the appropriate protection level is at Annex P.

14.3 Prohibited activities during refuelling

Vessels carrying explosives shall not refuel or transfer fuel unless the hatches to the explosive storage compartments are firmly secured. There shall be no handling of explosives during refuelling operations.

14.4 Measuring quantity distances (ports)

14.4.1. Measurements

All measurements are to be taken from the nearest point of the compartment storing explosives in a berthed or anchored vessel to the nearest ES.

14.4.2. Swinging circles

When estimating the appropriate QD allowances must be made for the movement of the vessel if it is anchored at a single buoy. The radius of the swinging circle, and effects of the tides, should be accounted for; anchor chain lengths are usually in the order of 40m for larger vessels

14.4.3. Multiple vessels

If more than one vessel carrying explosives is to be berthed or anchored, each should be considered to be a separate PES if appropriate separation distances can be achieved. If appropriate separation distance cannot be achieved, then both vessels should be considered as a single PES, with measurements to the ES taken accordingly from the nearest vessel to the ES.

14.5 Estimating quantity distances (ports)

14.5.1. Protection levels

The quantity distances recommended may only allow for a high degree of protection, as it is considered very unlikely that any vessel can provide a complete level of protection similar to that provided by an earth covered building.

14.5.2. Recommended quantity distances

Quantity distance tables containing the appropriate QD, (pre-calculated for a range of NEQ and safe distances), that should be used between vessels and differing ES are at Annex Q.

15 IATG software[19] and adjustment of quantity distances (LEVEL 2)

The IATG software is pre-loaded with the QD coefficients for above ground storage recommended within the annexes to this IATG. Nevertheless, the software allows users to enter their own QD coefficients. If coefficients are entered that are lower than those recommended within this IATG, then they should be supported by a full explosion consequence analysis in accordance with IATG 02.10 *Introduction to risk management processes and principles.*

[19] www.un.org/disarmament/un-saferguard/explosives-limit-license

Annex A
(normative)
References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this part of the guideline. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of the guideline are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO maintain registers of currently valid ISO or EN:

a) IATG 01.40 Glossary of *terms, definitions and appreciations*. UNODA. 2020;

b) IATG 01.50 *UN explosive classification system and codes*. UNODA. 2020;

c) IATG 01.80 *Formulae for ammunition management.* UNODA. 2020;

d) IATG 02.10 *Introduction to risk management principles and processes*. UNODA. 2020; and

e) IATG 02.30 *Licensing of explosive facilities*. UNODA. 2020.

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UNODA) holds copies of all references[20] used in this guideline and these can be found at: www.un.org/disarmament/un-saferguard/references/. A register of the latest version/edition of the International Ammunition Technical Guidelines is maintained by UNODA, and can be read on the IATG website: www.un.org/disarmament/ammunition/. National authorities, employers and other interested bodies and organisations should obtain copies before commencing conventional ammunition stockpile management programmes.

[20] Where copyright permits.

Annex B
(informative)
References

The following informative documents contain provisions, which should also be consulted to provide further background information to the contents of this guideline:[21]

f) AASTP-1, Edition B, Version 1,. *NATO Guidelines for the Storage of Military Ammunition and Explosives. (Part 1 General Principles and Guidelines for all Explosives Storage and Quantity Distance Tables for Above Ground Storage)*. NATO Standardization Office (NSO). December 2015;

g) AASTP-1, Edition B, Version 1,. *NATO Guidelines for the Storage of Military Ammunition and Explosives. (Part 3 Underground Explosives Storage)*. NATO Standardization Office (NSO). December 2015;

h) DSA03.OME part 2 provides for the safe storage and processing of Ordnance, Munitions and Explosives (OME). UK MOD. November 2020:

i) *Usage Manual for Missile and Artillery Armaments, Part 1, Use of Missile and Artillery Armaments by Troops*,[22] *Chapter 4.* USSR MOD. 1989;

j) DoDM 6055.09, *Ammunition and Explosives Safety Standards*. (Incorporating Change 1 (12 March 2012)). US Department of Defense. 29 February 2008; and

k) UFC-3-340-02, *Structures to Resist the Effects of Accidental Explosions*. US Department of Defense. 05 December 2008; Change 2, 01 September 2014. https://www.ddesb.pentagon.mil/documents/?pg=subcont-internationalissuances

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UNODA) holds copies of all references[23] used in this guideline and these can be found at: www.un.org/disarmament/un-saferguard/references/. A register of the latest version/edition of the International Ammunition Technical Guidelines is maintained by UNODA, and can be read on the IATG website: www.un.org/disarmament/ammunition/ . National authorities, employers and other interested bodies and organisations should obtain copies before commencing conventional ammunition stockpile management programmes.

[21] Data from many of these publications has been used to develop this IATG.

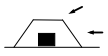
[22] Appendix 1 to Order of the Chief Commander of the Ground Forces No 5 1988.

[23] Where copyright permits.

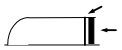
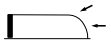
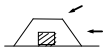
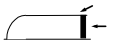
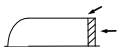
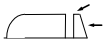
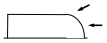
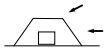
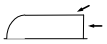
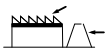
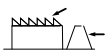
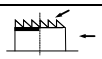
Annex C
(normative)
Symbols for QD concept (LEVEL 2)

The following symbols shall be used during the use of the QD concept within the IATG guidelines and supporting software. These are commonly used already by many States[24] and their use simplifies explanatory QD matrices and tables.

The symbols are purely diagrammatic and do not necessarily mean that the explosive storehouses should have similar shapes and proportions. The orientation shown is intended to indicate the direction of principle concern for blast, flame, radiant heat and projections, (shown by the arrows). When using the QD system every direction must be considered in turn. At a PES, there are relatively few significant variations, but at an ES it is necessary to distinguish among different types of construction, to include the presence of a barricade, and among different functions of buildings. For these reasons, a given building may require one symbol when it is being considered as a PES and a different symbol when it is considered as an ES. Further information on the directional effects of ECMs follows the Table C1.

Symbol	Type of Structure / Area	Description	Directional Effects
Potential Explosion Site (PES)			
	Earth covered magazine (ECM)	Building with earth on the roof and against three walls.	Front of magazine faces away from ES
	Earth covered magazine (ECM)	Building with earth on the roof and against three walls.	Side of magazine perpendicular to the direction of the ES.
	Earth covered magazine (ECM)	Building with earth on the roof and against three walls.	Front of magazine faces towards the ES.
	Reinforced ESH	Walls of nominal 450mm Reinforced Concrete (RC) (or 680mm Brick). Protective Roof of 150mm RC.	Any direction to the ES
	Reinforced ESH	Walls of nominal 450mm Reinforced Concrete (RC) (or 680mm Brick). Protective Roof of 150mm RC.	Door or other large opening faces towards the ES.
	Semi-Reinforced ESH	Walls of nominal 450mm Reinforced Concrete (RC) (or 680mm Brick). No Protective Roof.	Any direction to ES.
	Medium Building, Barricaded	Walls of minimum 215mm brick, or equivalent. Protective roof of 150mm RC.	Barricaded side to ES.
	Medium Building	Walls of minimum 215mm brick, or equivalent. Protective roof of 150mm RC.	Any direction to ES.
	Light Building or Open Stack, Barricaded	Light building or open stack of ammunition with an effective barricade	Barricaded side to ES
	Light Building or Open Stack	Light building or open stack of ammunition.	Any direction to ES.
Exposed Site (ES)			
	Standard NATO ECM	Building with earth on the roof and against three walls. 7BAR Door.	Door facing away from PES.
	Standard NATO ECM	Building with earth on the roof and against three walls. 7BAR Headwall and Door.	Door facing perpendicular to the direction of the PES.

[24] They form the basis of the QD system within NATO AASTP-1, which is also used by many non-NATO States around the world.

Symbol	Type of Structure / Area	Description	Directional Effects
	Standard NATO ECM	Building with earth on the roof and against three walls. 7BAR Headwall and Door.	Door facing towards a PES.
	NATO Standard ECM	Building with earth on the roof and against three walls. 3BAR Headwall and Door.	Door facing away from PES.
	NATO Standard ECM	Building with earth on the roof and against three walls. 3BAR Headwall and Door.	Door facing perpendicular to a PES.
	NATO Standard ECM	Building with earth on the roof and against three walls. 3BAR Headwall and Door.	Door facing towards a PES.
	Undefined ECM	Building with earth on the roof and against three walls. Headwall and door resistant to high velocity projections.	Door facing towards a PES.
	Undefined ECM	Building with earth on the roof and against three walls and weaker than above magazines. Barricade in front of door and headwall that may or may not be resistant to low velocity fragments.	Door facing towards a PES.
	Undefined ECM	Building with earth on the roof and against three walls. Headwall and door may or may not be resistant to low velocity projections.	Door facing away from PES.
	Undefined ECM	Building with earth on the roof and against three walls. Headwall and door may or may not be resistant to low velocity projections.	Door facing perpendicular to PES.
	Undefined ECM	Building with earth on the roof and against three walls. Headwall and door may or may not be resistant to low velocity projections.	Door facing towards a PES.
	Reinforced ESH	Walls of nominal 450mm Reinforced Concrete (RC) (or 680mm Brick). Protective Roof of 150mm RC.	Any direction to PES.
	Semi-Reinforced ESH	Walls of nominal 450mm Reinforced Concrete (RC) (or 680mm Brick). No Protective Roof.	Any direction to PES.
	Medium Building, Barricaded	Walls of minimum 215mm brick, or equivalent. Protective roof of 150mm RC.	Barricaded side to PES.
	Medium Building	Walls of minimum 215mm brick, or equivalent. Protective roof of 150mm RC.	Any direction to PES.
	Light Building or Open Stack, Barricaded	Light Building or Open stack of ammunition with an effective r barricade.	Barricaded side to PES.
	Light Building or Open Stack	Light Building or Open stack of ammunition with no protection.	Any direction to PES.
	Ammunition Process Building (APB), Barricaded	Protective roof.	Barricaded side to PES.
	Ammunition Process Building (APB), Barricaded	No protective roof.	Barricaded side to PES.
	Ammunition Process Building (APB)	No protective roof or barricade.	Any direction to PES.
	Public Traffic Route (PTR)	Road, Railway, Waterway or Right of Way. Usage density will be shown in QD Matrix.	Any direction to PES.
	Inhabited Building	Civilian Buildings or Places of Assembly.	Any direction to PES.

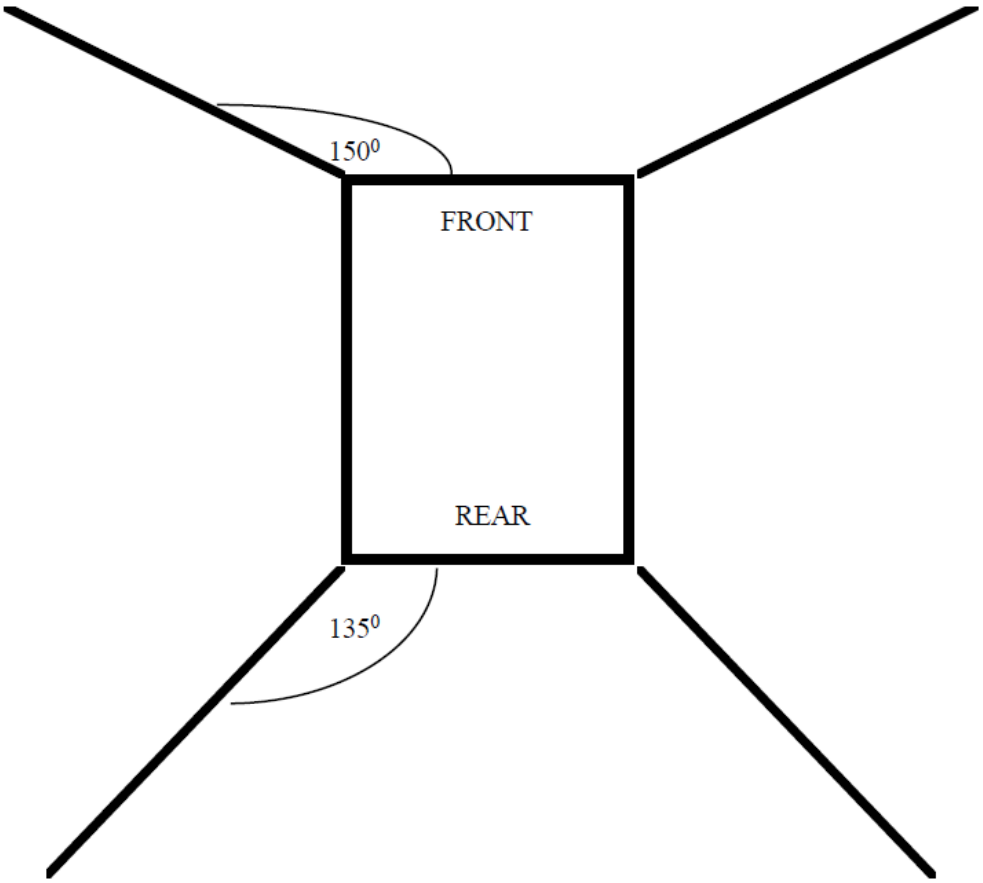
Symbol	Type of Structure / Area	Description	Directional Effects
	Vulnerable Building	Hospitals, Glass facade Buildings etc.	Any direction to PES.

Table C.1: QD Symbology

Directional effects from ECMs with HD 1.1

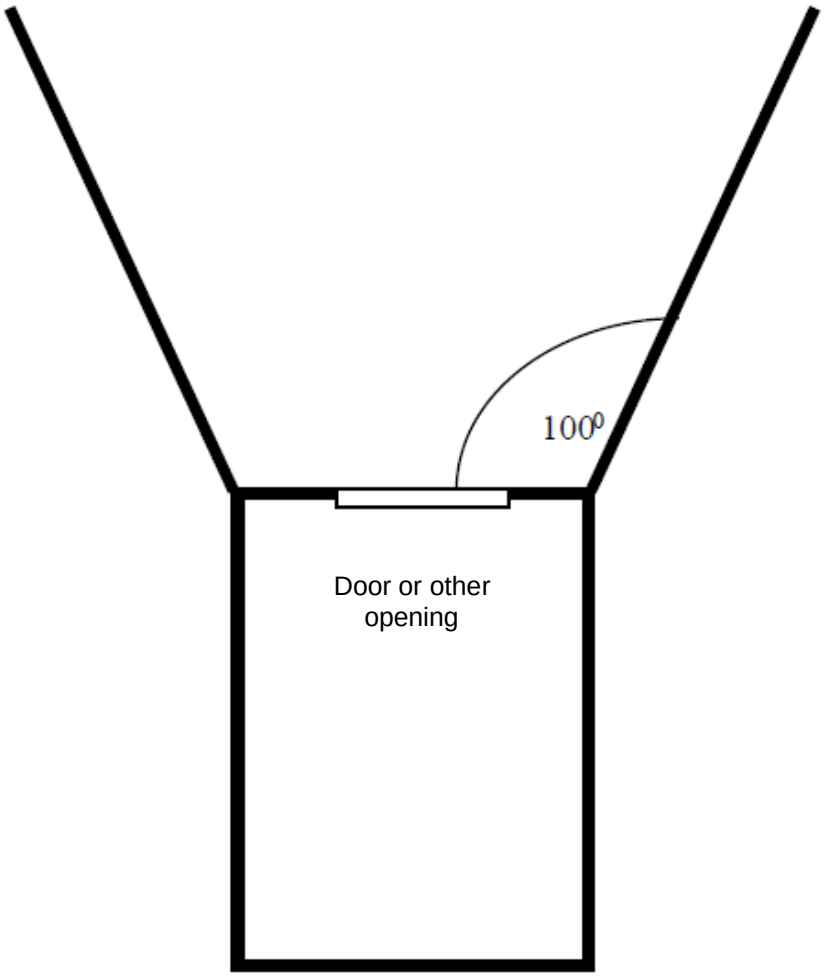
The directional effects for HD 1.1 or HD 1.3 from buildings which meet the design criteria for ECMs are considered to occur:

a. Through the front in the area bounded by lines drawn at 150º to the front face of the PES from its front corners.
b. Through the rear in the area bounded by lines drawn at 135º to the rear face of the PES from its rear corners
c. All area around a PES not included in a. or b. above are considered to be to the side of the PES. In those cases where an ES lies on the line separating rear/side of a PES, the greater QD should be observed.



Directional effects from ECMs with HD 1.2

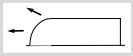
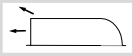
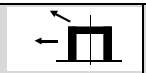
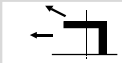
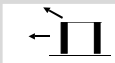
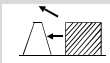
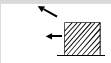
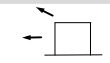
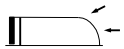
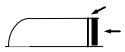
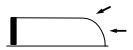
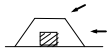
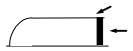
The directional effects for HD 1.2 from buildings which meet the design criteria for ECMs or HD 1.2 containment buildings are considered to occur through the front in the area bounded by lines drawn at 100^{o} to the front face of the PES from its corners.

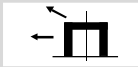
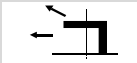
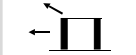
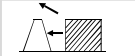
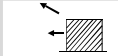
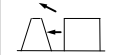
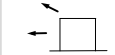
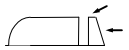
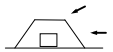
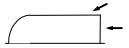


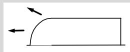
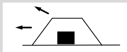
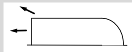
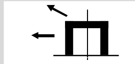
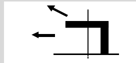
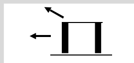
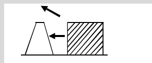
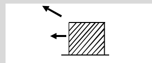
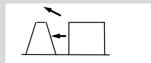
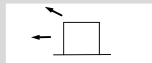
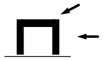
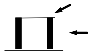
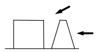
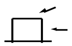
Annex D
(normative)

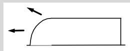
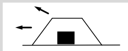
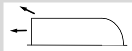
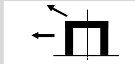
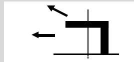
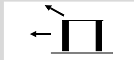
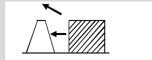
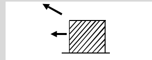
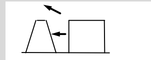
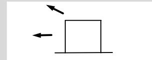
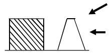
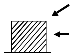
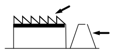
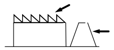
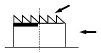
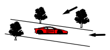
Hazard division 1.1 QD matrix (above ground storage) (LEVEL 1)

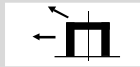
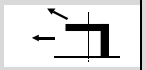
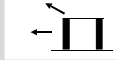
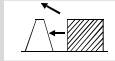
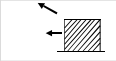
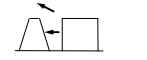
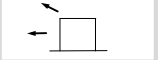
D.1 NEQ (>50kg)

PES ⇒ ES ⇓										
	**D3** Virtually Complete Protection	**D3** Virtually Complete Protection	**D4** Virtually Complete Protection	**D5** Virtually Complete Protection	**D5** Virtually Complete Protection	**D5** Virtually Complete Protection	**D5** Virtually Complete Protection	**D5** Virtually Complete Protection	**D5** Virtually Complete Protection	**D5** Virtually Complete Protection
	**D3** Virtually Complete Protection	**D3** Virtually Complete Protection	**D5** Virtually Complete Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection
	**D4** Virtually Complete Protection	**D5** Virtually Complete Protection **or D4** High Degree of Protection	**D8** High Degree of Protection	**D8** High Degree of Protection **or D12** Virtually Complete Protection	**D8** High Degree of Protection **or D12** Virtually Complete Protection	**D8** High Degree of Protection **or D12** Virtually Complete Protection	**D8** High Degree of Protection	**D8** High Degree of Protection	**D8** High Degree of Protection	**D8** High Degree of Protection
	**D3** Virtually Complete Protection	**D3** Virtually Complete Protection	**D4** Virtually Complete Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection
	**D3** Virtually Complete Protection	**D3** Virtually Complete Protection	**D5** Virtually Complete Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection
	**D6** Virtually Complete Protection	**D6** Virtually Complete Protection	**D8** High Degree of Protection	**D9** High Degree of Protection **or D12** Virtually Complete Protection	**D9** High Degree of Protection **or D12** Virtually Complete Protection	**D9** High Degree of Protection **or D12** Virtually Complete Protection	**D8** High Degree of Protection	**D8** High Degree of Protection	**D8** High Degree of Protection	**D8** High Degree of Protection
	D4 High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spa **or D7** High Degree of Protection	**D9** Limited Degree of Protection	**D9** Limited Degree of Protection	**D9** Limited Degree of Protection	**D9** Limited Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D9** High Degree of Protection	**D9** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D9** High Degree of Protection	**D9** High Degree of Protection

PES ⇒ ES ⇓										
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D9** Limited Degree of Protection	**D9** High Degree of Protection	**D9** High Degree of Protection	**D9** High Degree of Protection	**D9** High Degree of Protection	**D9** High Degree of Protection	**D9** High Degree of Protection	**D9** High Degree of Protection
	**D4** Virtually Complete Protection No primary explosives No items vulnerable to spall **or D5** Virtually complete protection No primary explosives	**D4** Virtually Complete Protection No primary explosives No items vulnerable to spall **or D5** Virtually complete protection No primary explosives	**D4** High Degree of Protection No primary explosives No items vulnerable to spall Effect of lobbed ammunition **or D6** Virtually Complete Protection Effect of lobbed ammunition	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection
	**D6** Virtually Complete Protection **or D4** High Degree of Protection **No primary explosives** **No items vulnerable to spall**	**D6** Virtually Complete Protection **or D4** High Degree of Protection **No primary explosives** **No items vulnerable to spall**	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D9** Limited Degree of Protection	**D9** Limited Degree of Protection	**D9** Limited Degree of Protection	**D9** Limited Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D9** Limited Degree of Protection	**D9** Limited Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D9** Limited Degree of Protection	**D9** Limited Degree of Protection

PES ⇒ ES ⇓										
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D5** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D5** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** Limited Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection **D1/D2** High Degree of Protection Open bomb bay storage	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection **D1/D2** High Degree of Protection Open bomb bay storage
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D9** Limited Degree of Protection **or D12** High Degree of Protection	**D9** Limited Degree of Protection **or D12**	**D9** Limited Degree of Protection **or D12**	**D9** Limited Degree of Protection **or D12**	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D9** Limited Degree of Protection **or D12**	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection **D1/D2** High Degree of Protection Open bomb bay storage	**D9** Limited Degree of Protection **or D12**

PES ⇒ ES ⇓										
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection
	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D9** Limited Degree of Protection **or D12** High Degree of Protection	**D9** Limited Degree of Protection **or D12**	**D9** Limited Degree of Protection **or D12**	**D9** Limited Degree of Protection **or D12**	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D9** Limited Degree of Protection **or D12**	**D4** High Degree of Protection No primary explosives No items vulnerable to spall **or D7** High Degree of Protection	**D9** Limited Degree of Protection **or D12**
	**D9** Less than 10 personnel **D10** Limited Degree of Personnel Protection	**D9** Less than 10 personnel **D10** Limited Degree of Personnel Protection	**D9** Less than 10 personnel **D10** Limited Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection
	**D10** (≥270m) Limited Degree of Personnel Protection	**D10** (≥270m) Limited Degree of Personnel Protection	**D10** (≥270m) Limited Degree of Personnel Protection	**D10** (≥270m) Limited Degree of Personnel Protection	**D10** (≥270m) Limited Degree of Personnel Protection	**D10** (≥270m) Limited Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection
	**D10** (≥270m) Limited Degree of Personnel Protection	**D10** (≥270m) Limited Degree of Personnel Protection	**D13** (≥270m) Limited Degree of Personnel Protection	**D13** Limited Degree of Personnel Protection	**D13** Limited Degree of Personnel Protection	**D13** Limited Degree of Personnel Protection	**D9** (≥270m) Less than 10 personnel **D10** (≥270m) High Degree of Personnel Protection	**D13** High Degree of Personnel Protection	**D9** Less than 10 personnel **D10** High Degree of Personnel Protection	**D13** High Degree of Personnel Protection
 PTR Low Density. No QD for very low density PRT and Roads.	**0.5 x D12** **or** **0.5 x D14** Reduced QD for standard ECM	**0.5 x D12** **or** **0.5 x D15** Reduced QD for standard ECM	**0.5 x D12**	**0.5 x D12**	**0.5 x D12**	**0.5 x D12**	**0.5 x D12**	**0.5 x D12**	**0.5 x D12**	**0.5 x D12**

PES ⇒ **ES ⇓**										
 PTR Medium Density	**D11** (≥270m) **or** **D16** Reduced QD for standard ECM	**D11** (≥270m) **or** **D17** Reduced QD for standard ECM	**D11** (≥270m)	**D11** (≥270m)	**D11** (≥270m)	**D11** (≥270m)	**D11** (≥180m)	**D11** (≥270m)	**D11** (≥180m)	**D11** (≥270m)
 PTR High Density	**D13** (≥400m) **or** **D14** Reduced QD for standard ECM	**D13** (≥400m) **or** **D15** Reduced QD for standard ECM	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥270m)	**D13** (≥400m)	**D13** (≥270m)	**D13** (≥400m)
 IBD	**D13** (≥400m) **or** **D14** Reduced QD for standard ECM	**D13** (≥400m) **or** **D15** Reduced QD for standard ECM	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)
 VBD	**2 x D12** **or** **2 x D14** Reduced QD for standard ECM	**2 x D12** **or** **2 x D15** Reduced QD for standard ECM	**2 x D12**	**2 x D12**	**2 x D12**	**2 x D12**	**2 x D12**	**2 x D12**	**2 x D12**	**2 x D12**
Office <20 Support staff working in explosives area	**D11** (≥270m) **or** **D16** Reduced QD for standard ECM	**D11** (≥270m) **or** **D17** Reduced QD for standard ECM	**D11** (≥270m)	**D11** (≥270m)	**D11** (≥270m)	**D11** (≥270m)	**D11** (≥180m)	**D11** (≥270m)	**D11** (≥180m)	**D11** (≥270m)
Office >20 Support staff working in explosives area	**D13** (≥400m) **or** **D14** Reduced QD for standard ECM	**D13** (≥400m) **or** **D15** Reduced QD for standard ECM	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥270m)	**D13** (≥400m)	**D13** (≥270m)	**D13** (≥400m)

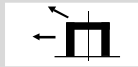
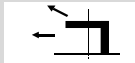
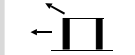
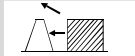
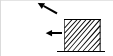
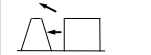
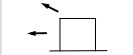
PES ⇒ **ES ⇓**										
Overhead Power Grid Super Network	**D13 or D14** Reduced QD for standard ECM	**D13 or D15** Reduced QD for standard ECM	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**
Normal Network			**D11**	**D11**	**D11**	**D11**	**D11**	**D11**	**D11**	**D11**
Minor Network	**D11 or D16** Reduced QD for standard ECM	**D11 or D17** Reduced QD for standard ECM	**D10**	**D10**	**D10**	**D10**	**D10**	**D10**	**D10**	**D10**
	D10 Reduced QD for standard ECM	**D10**								
POL Facilities Protected or Underground	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)	**0.5 x D7** (≥25m)
Unprotected, Above Ground and Vital	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)	**D13** (≥400m)
Unprotected, Above Ground Minor facilities	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**	**D13**
Small Quantity < 100 litres of petroleum, oils and lubricants held as immediate reserves for operational purposes.	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**

Table D.1: QD Matrix for HD 1.1 (Above Ground Storage) (>50kg)

Annex E
(normative)

Hazard division 1.1 QD tables (above ground storage) (LEVEL 1)

E.1 NEQ (>50kg)

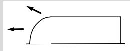
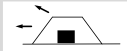
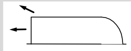
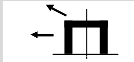
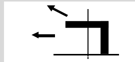
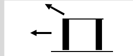
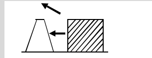
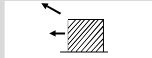
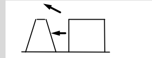
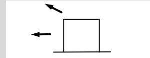
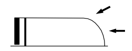
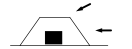
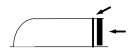
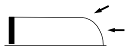
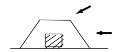
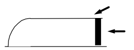
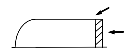
NEQ (kg)	Quantity Distances (metres)																
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17
>50	3		5	7	9	15	20	29	39	64	147	85	220	220	220	220	220
75	3		5	7	9	15	20	29	39	64	147	95	220	258	258	258	258
100	3		5	7	9	15	20	29	39	64	160	105	240	294	294	240	240
200	3		5	7	9	15	20	29	39	64	180	130	270	376	376	270	270
300	3		5	7	9	15	20	29	39	64	180	150	270	400	400	270	270
400	3		5	7	9	15	20	29	39	64	180	165	270	400	400	270	270
500	3		5	7	9	15	20	29	39	64	180	180	270	400	400	270	270
600	3		5	7	10	16	21	31	41	68	180	190	270	400	400	270	270
700	4		5	8	10	16	22	32	43	72	180	200	270	400	400	270	270
800	4		5	8	11	17	23	34	45	75	180	210	270	400	400	270	270
900	4		5	8	11	18	24	35	47	78	180	215	270	400	400	270	270
1,000	4		5	8	11	18	24	36	48	80	180	225	270	400	400	270	270
1,200	4		6	9	12	20	26	39	52	86	180	240	270	400	400	270	270
1,400	4		6	9	13	21	27	41	54	90	180	250	270	400	400	270	270
1,600	5		6	10	13	22	29	43	57	94	180	260	270	400	400	270	270
1,800	5		7	10	14	22	30	44	59	98	180	270	270	400	400	270	270
2,000	5		7	11	14	23	31	46	61	105	180	280	270	400	400	270	270
2,500	5		7	11	15	25	33	49	66	110	185	305	280	400	400	270	270

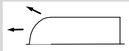
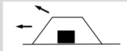
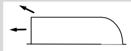
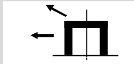
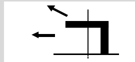
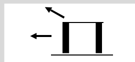
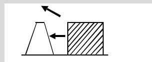
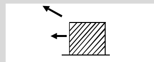
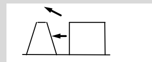
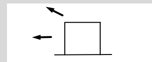
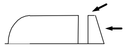
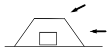
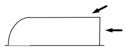
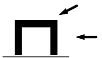
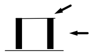
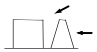
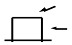
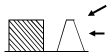
NEQ (kg)	Quantity Distances (metres)																
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17
3,000	6		8	12	16	26	35	52	70	120	205	325	305	400	400	270	270
3,500	6		8	13	17	28	37	55	73	125	220	340	330	400	400	270	270
4,000	6		8	13	18	29	39	58	77	130	235	355	350	400	400	270	270
5,000	6		9	14	19	31	42	62	83	140	255	380	380	400	400	270	270
6,000	7		10	15	20	33	44	66	88	150	270	405	405	400	400	270	270
7,000	7		10	16	22	35	46	69	92	155	285	425	425	400	400	270	270
8,000	7		10	16	22	36	48	72	96	160	300	445	445	400	400	270	270
9,000	8		11	17	23	38	50	75	100	170	310	465	465	400	400	270	270
10,000	8		11	18	24	39	52	78	105	175	320	480	480	400	400	270	270
12,000	9		12	19	26	42	55	83	110	185	340	510	510	400	415	270	275
14,000	9		13	20	27	44	58	87	120	195	360	540	540	400	435	270	290
16,000	10		13	21	28	46	61	91	125	205	375	560	560	400	455	270	305
18,000	10		14	21	29	48	63	95	130	210	390	590	590	400	475	270	315
20,000	10		14	22	30	49	66	98	135	220	405	610	610	400	490	270	330
25,000	11		15	24	33	53	71	110	145	235	435	650	650	410	530	275	355
30,000	11		16	25	35	56	75	115	150	250	460	690	690	435	560	290	375
35,000		15	17	27	36	59	79	120	160	265	485	730	730	460	580	305	395
40,000		16	18	28	38	62	82	125	165	275	510	760	760	500	620	320	415
50,000		17	19	30	41	67	89	135	180	295	550	820	820	515	663	343	442
60,000		18	20	32	44	71	94	145	190	315	580	870	870	548	705	364	470
70,000		19	21	33	46	75	99	150	200	330	610	920	920	577	742	383	495
80,000		19	22	35	48	78	105	160	210	345	640	960	960	603	776	401	517
90,000		20	23	36	50	81	110	165	220	360	670	1000	1000	627	807	417	538
100,000		21	24	38	52	84	115	170	225	375	690	1040	1040	650	835	432	557
120,000		22	25	40	55	89	120	180	240	395	730	1100	1100	690	887	459	592

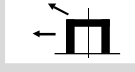
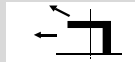
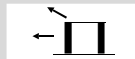
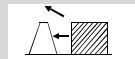
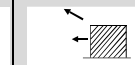
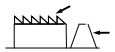
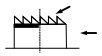
NEQ (kg)	Quantity Distances (metres)																
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17
140,000			26	42	58	94	125	190	250	420	770	1160	1160	727	935	483	623
160,000			28	44	60	98	135	200	265	435	810	1220	1220	760	977	505	651
180,000			29	46	63	105	140	205	275	455	840	1260	1260	790	1016	525	678
200,000			30	47	65	110	145	215	285	470	870	1300	1300	819	1053	544	702
250,000			32	51	70	115	155	230	305	510	940	1400	1400	882	1134	586	756
CAUTION Check the Q root.	**$0.35Q^{1/3}$**	**$0.44Q^{1/3}$**	**$0.5Q^{1/3}$**	**$0.8Q^{1/3}$**	**$1.1Q^{1/3}$**	**$1.8Q^{1/3}$**	**$2.4Q^{1/3}$**	**$3.6Q^{1/3}$**	**$4.8Q^{1/3}$**	**$8.0Q^{1/3}$**	**$1.0Q^{2/3}$ for Q<2500 $3.6Q^{1/2}$ for Q>2500 $14.8Q^{1/3}$ for Q>4500**	**$22.2Q^{1/3}$**	**$1.5Q^{2/3}$ for Q<2500 $5.5Q^{1/2}$ for Q>2500 $22.2Q^{1/3}$ for Q>4500**	**$14.0Q^{1/3}$**	**$18.0Q^{1/3}$**	**$9.3Q^{1/3}$**	**$12.0Q^{1/3}$**

Table E.1: QD Table for HD 1.1 (Above Ground Storage) (>50kg)

Annex F
(normative)
Hazard division 1.2.1 QD matrix (above ground storage) (LEVEL 1)

PES ⇒ ES ⇓										
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection

PES ⇒ ES ⇓										
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D6** Limited Degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection	**D6** High Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D6** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D6** Limited degree of Protection	**D6** Limited degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D6** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D6** Limited degree of Protection	**D6** Limited degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D6** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D6** Limited degree of Protection	**D6** Limited degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection	**D6** Limited Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D5** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**No QD** High Degree of Protection	**No QD** High Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection

PES ⇒ **ES ⇓**										
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D5** High Degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**No QD** High Degree of Protection	**No QD** High Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection
	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons
	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D4** Limited Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D4** High/Limited Degree of Protection for Persons	**D4** Limited Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons	**D4** High Degree of Protection for Persons rapidly evacuated
	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D6** Limited Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D6** Limited Degree of Protection for Persons	**D6** Limited Degree of Protection for Persons	**D6** High Degree of Protection for Persons	**D6** High Degree of Protection for Persons	**D6** High Degree of Protection for Persons	**D6** High Degree of Protection for Persons
 PTR Low Density. No QD for very low density PRT and Roads.	**No QD**	**No QD**	**0.5 x D2**	**No QD**	**0.5 x D2**	**0.5 x D2**	**0.5 x D2**	**0.5 x D2**	**0.5 x D2**	**0.5 x D2**
 PTR Medium Density	**No QD**	**No QD**	**D6**	**No QD**	**D6**	**D6**	**D6**	**D6**	**D6**	**D6**
 PTR High Density	**60m**	**60m**	**D2**	**60m**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
 IBD	**60m**	**60m**	**D2**	**60m**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
 VBD	**60m**	**60m**	**D2**	**60m**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**

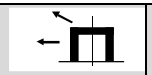
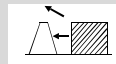
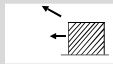
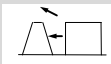
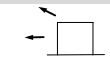
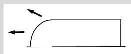
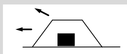
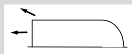
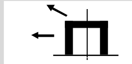
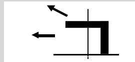
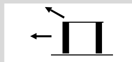
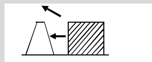
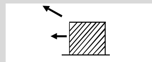
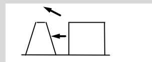
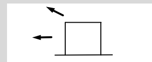
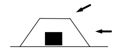
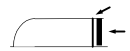
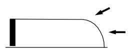
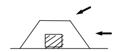
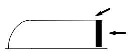
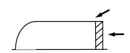
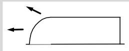
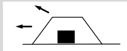
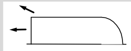
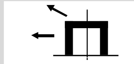
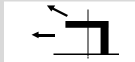
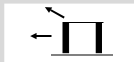
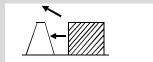
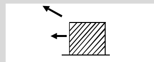
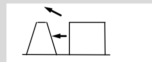
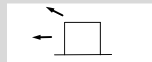
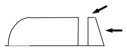
PES ⇒ **ES ⇓**										
Office <20 Support staff working in explosives area	**40m**	**40m**	**D6**	**40m**	**D6**	**D6**	**D6**	**D6**	**D6**	**D6**
Office >20 Support staff working in explosives area	**60m**	**60m**	**D2**	**60m**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
Overhead Power Grid Super Network	**60m**	**60m**	**D2**	**60m**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
Normal Network	**30m**	**30m**	**D6**	**30m**	**D6**	**D6**	**D6**	**D6**	**D6**	**D6**
Minor Network	**No QD**	**No QD**	**D4**	**No QD**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
POL Facilities Protected or Underground	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**
Unprotected, Above Ground and Vital	**60m**	**60m**	**D2**	**60m**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
Unprotected, Above Ground	**30m**	**30m**	**D6**	**30m**	**D6**	**D6**	**D6**	**D6**	**D6**	**D6**
Small Quantities. < 100 litres of petroleum, oils and lubricants held as immediate reserves for operational purposes.	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**

Table F.1: QD Matrix for HD 1.2.1 (Above Ground Storage)

Annex G
(normative)
Hazard division 1.2.2 QD matrix (above ground storage) (LEVEL 1)

PES ⇒ ES ⇓										
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection

PES ⇒ **ES ⇓**										
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
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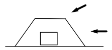
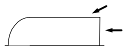
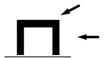
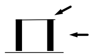
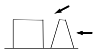
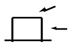
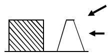
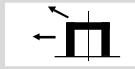
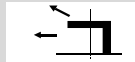
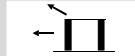
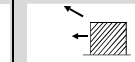
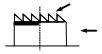
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** High Degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**No QD** High Degree of Protection	**No QD** High Degree of Protection	**D5** High Degree of Protection	**D5** High Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D5** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** Limited degree of Protection	**D5** Limited degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D5** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** Limited degree of Protection	**D5** Limited degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D5** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** Limited degree of Protection	**D5** Limited degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D5** Limited degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**No QD** High Degree of Protection	**No QD** High Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection

PES ⇒ ES ⇓										
	**No QD** Virtually Complete Protection	**No QD** Virtually Complete Protection	**D5** High Degree of Protection	**No QD** These combinations of structures will always provide virtually complete protection	**D5** High Degree of Protection	**D5** High Degree of Protection	**No QD** High Degree of Protection	**No QD** High Degree of Protection	**D5** Limited Degree of Protection	**D5** Limited Degree of Protection
	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D3** Limited Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D3** High Degree of Protection for Persons	**D3** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D3** High Degree of Protection for Persons	**D3** High Degree of Protection for Persons
	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D3** Limited Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D3** Limited Degree of Protection for Persons	**D3** Limited Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D3** Limited Degree of Protection for Persons	**D3** Limited Degree of Protection for Persons
	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D5** Limited Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D5** Limited Degree of Protection for Persons	**D5** Limited Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**No QD** High Degree of Protection for Persons	**D5** Limited Degree of Protection for Persons	**D5** Limited Degree of Protection for Persons
 PTR Low Density No QD for very low density PRT and Roads.	**No QD**	**No QD**	**0.5 x D1**	**No QD**	**0.5 x D1**	**0.5 x D1**	**No QD**	**No QD**	**0.5 x D1**	**0.5 x D1**
 PTR Medium Density	**20m**	**20m**	**D5**	**20m**	**D5**	**D5**	**D5**	**D5**	**D5**	**D5**
 PTR (High Density)	**30m**	**30m**	**D1**	**30m**	**D1**	**D1**	**D1**	**D1**	**D1**	**D1**
 IBD	**30m**	**30m**	**D1**	**30m**	**D1**	**D1**	**D1**	**D1**	**D1**	**D1**
 VBD	**30m**	**30m**	**D1**	**30m**	**D1**	**D1**	**D1**	**D1**	**D1**	**D1**
Office <20 Support staff working in explosives area	**20m**	**20m**	**D5**	**20m**	**D5**	**D5**	**D5**	**D5**	**D5**	**D5**

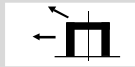
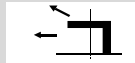
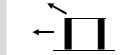
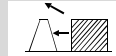
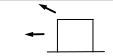
PES ⇒ **ES ⇓**										
Office >20 Support staff working in explosives area	**30m**	**30m**	**D1**	**30m**	**D1**	**D1**	**D1**	**D1**	**D1**	**D1**
Overhead Power Grid Super Network	**30m**	**30m**	**D1**	**30m**	**D1**	**D1**	**D1**	**D1**	**D1**	**D1**
Normal Network	**15m**	**15m**	**D5**	**15m**	**D5**	**D5**	**D5**	**D5**	**D5**	**D5**
Minor Network	**No QD**	**No QD**	**D3**	**No QD**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
POL Facilities Protected or Underground	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**
Unprotected, Above Ground and Vital	**30m**	**30m**	**D1**	**30m**	**D1**	**D1**	**D1**	**D1**	**D1**	**D1**
Unprotected, Above Ground	**15m**	**15m**	**D5**	**15m**	**D5**	**D5**	**D5**	**D5**	**D5**	**D5**
Small Quantities < 100 litres of petroleum, oils and lubricants held as immediate reserves for operational purposes.	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**	**No QD**

Table G.1: QD Matrix for HD 1.2.2 (Above Ground Storage)

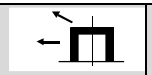
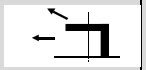
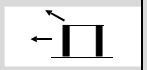
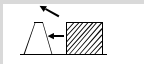
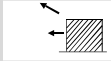
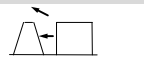
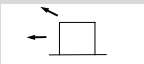
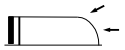
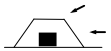
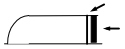
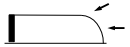
Annex H
(normative)
Hazard division 1.2 QD tables (above ground storage) (LEVEL 1)

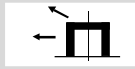
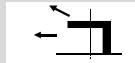
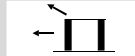
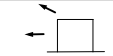
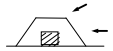
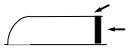
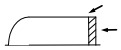
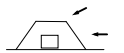
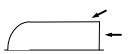
NEQ (kg)	Quantity Distances (m)					
	D1	D2	D3	D4	D5	D6
10	30	60	20	20	30	60
20	36	60	20	20	30	60
50	44	88	20	32	30	60
70	47	110	20	39	32	73
80	49	120	20	42	33	78
90	50	125	20	45	34	83
100	51	130	20	47	35	87
120	53	140	20	51	36	94
140	55	150	20	54	37	100
160	57	160	21	57	39	105
180	59	165	22	59	40	110
200	60	170	22	61	41	115
250	64	185	24	66	43	125
300	66	195	24	70	45	130
350	69	200	25	72	47	135
400	71	210	26	75	48	140
500	75	220	27	80	51	150
600	78	230	29	83	53	155
700	81	240	30	86	55	160
800	83	245	30	89	56	165
900	86	255	31	91	58	170
1,000	88	260	32	93	59	175
1,200	91	270	33	96	61	180
1,400	94	275	34	99	63	185
1,600	97	285	35	105	65	190
1,800	100	290	36	105	67	195
2,000	105	295	37	110	69	200
2,500	110	305	39	115	72	205
3,000	115	315	40	115	75	210
3,500	115	320	42	120	77	215
4,000	120	330	43	120	80	220
4,500	120	335	44	120	81	225
5,000	125	340	45	125	83	230
6,000	130	350	46	125	86	235
7,000	135	355	48	130	88	240
8,000	135	360	49	130	91	245
9,000	140	365	50	135	93	245

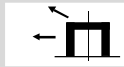
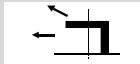
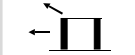
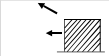
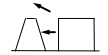
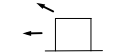
NEQ (kg)	Quantity Distances (m)					
	D1	D2	D3	D4	D5	D6
10,000	145	370	51	135	95	250
12,000	150	380	53	140	98	255
14,000	150	390	54	140	105	260
16,000	155	395	56	145	105	265
18,000	160	400	57	145	110	270
20,000	160	405	58	145	110	275
25,000	170	415	60	150	115	280
30,000	175	420	62	155	120	285
35,000	180	430	64	155	120	290
40,000	185	435	66	160	125	295
45,000	185	440	67	160	125	295
50,000	190	445	68	160	130	300
60,000	195	450	70	165	130	305
70,000	200	455	72	165	135	305
80,000	205	465	74	170	140	310
90,000	210	470	75	170	140	315
100,000	215	470	76	170	145	315
120,000	220	480	79	175	150	320
140,000	225	485	80	175	150	325
160,000	230	490	82	180	155	330
180,000	235	495	84	180	155	335
200,000	235	500	85	180	160	335
250,000	245	510	88	185	165	340
500,000	270	540	97	195	185	360
CAUTION Check the Q root.	**$D1 = 28.127 - 2.364 * LN(NEQ) + 1.577 * ((LN(NEQ))^2)$**	**$D\ 2 = -167.648 + 70.345 * LN(NEQ) - 1.303 * ((LN(NEQ))^2)$**	**0.36*D1**	**0.36*D2**	**0.67*D1**	**0.67*D2**

Table H.1: QD Table for HD 1.2 (Above Ground Storage)

Annex J
(normative)
Hazard division 1.3.1 QD matrix (above ground storage) (LEVEL 1)

PES ⇒ ES ⇓										
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection

PES ⇒ ES ⇓										
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection
	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**D1** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**D1** High Degree of Protection	**25m** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection
	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**D1** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**D1** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection
	**25m** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection

PES ⇒ ES ⇓										
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High/Limited degree of protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High degree of protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High/Limited degree of protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High/Limited degree of protection
	**25m** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** High Degree of Protection	**D1** High/Limited Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High/Limited Degree of Protection	**D1** High/Limited Degree of Protection
	**25m** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High/Limited Degree of Protection	**D1** High/Limited Degree of Protection
	**25m** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High Degree of Protection	**D1** High/Limited Degree of Protection	**D1** High/Limited Degree of Protection
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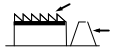
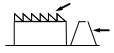
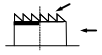
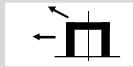
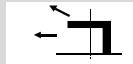
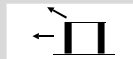
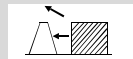
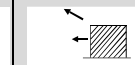
	**25m** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** High/Limited Degree of Protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection
	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**

PES ⇒ **ES ⇓**										
 PTR Low Density No QD for very low density PRT and Roads.	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**
 PTR Medium Density	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
 PTR High Density	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
 IBD	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
 VBD	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Office <20 Support staff working in explosives area	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
Office >20 Support staff working in explosives area	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Overhead Power Grid Super Network	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Normal Network	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
Minor Network	**D2**	**D2**	**D2**	**D2** (>15m)	**D2** (>15m)	**D2** (>15m)	**D2** (>15m)	**D2** (>15m)	**D2** (>15m)	**D2** (>15m)

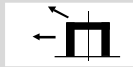
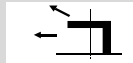
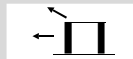
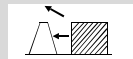
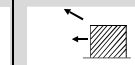
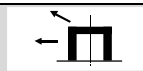
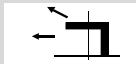
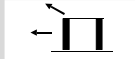
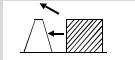
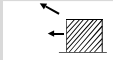
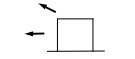
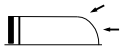
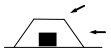
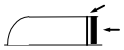
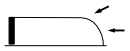
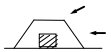
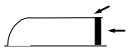
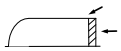
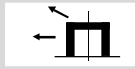
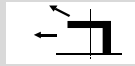
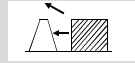
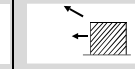
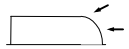
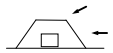
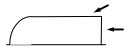
PES ⇒ **ES ⇓**										
POL Facilities Protected or Underground	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**
Unprotected, Above Ground and Vital	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Unprotected, Above Ground	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
Small Quantities < 100 litres of petroleum, oils and lubricants held as immediate reserves for operational purposes.	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**

Table J.1: QD Matrix for HD 1.3.1 (Above Ground Storage)

Annex K
(normative)
Hazard division 1.3.2 QD matrix (above ground storage) (LEVEL 1)

PES ⇒ ES ⇓										
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m**These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection	**10m** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection

PES ⇒ ES ⇓										
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**D1** These combinations of structures will always provide virtually complete protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**25m** These combinations of structures will always provide virtually complete protection **10m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection	**No QD** These combinations of structures will always provide virtually complete protection
	**No QD** These combinations of structures will always provide virtually complete protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection
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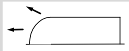
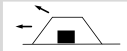
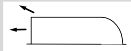
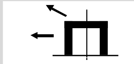
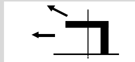
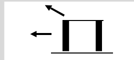
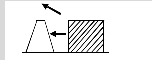
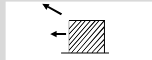
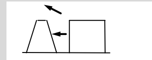
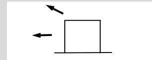
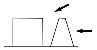
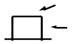
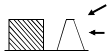
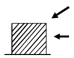
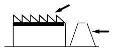
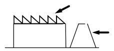
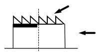
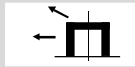
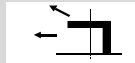
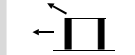
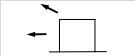
PES ⇒ ES ⇓										
	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection
	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection
	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection
	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** These combinations of structures will always provide virtually complete protection **25m** High/Limited degree of protection	**60m** High/Limited Degree of Protection	**10m** These combinations of structures will always provide virtually complete protection	**60m** High Degree of Protection	**10m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection
	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**
	**60m**	**60m**	**60m**	**60m**	**60m**	**60m**	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection
	**60m**	**60m**	**60m**	**60m**	**25m**	**60m**	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection	**60m** High/Limited Degree of Protection

PES ⇒ **ES ⇓**										
 PTR Low Density No QD for very low density PRT and Roads.	**60m**	**60m**	**60m**	**60m**	**60m**	**60m**	**60m**	**60m**	**60m**	**60m**
 PTR Medium Density	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
 PTR High Density	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
 IBD	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
 VBD	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Office <20 Support staff working in explosives area	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
Office >20 Support staff working in explosives area	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Overhead Power Grid Super Network	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Normal Network	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
Minor Network	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**	**D2**

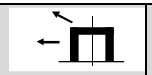
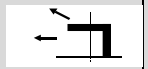
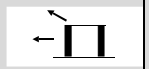
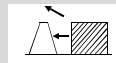
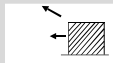
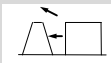
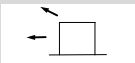
PES ⇒ **ES ⇓**										
POL Facilities	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**	**25m**
Protected or Underground	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**	**D4**
Unprotected, Above Ground and Vital	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**	**D3**
Unprotected, Above Ground Small Quantities < 100 litres of petroleum, oils and lubricants held as immediate reserves for operational purposes.	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**	**10m**

Table K.1: QD Matrix for HD 1.3.2 (Above Ground Storage)

Annex L
(normative)
Hazard division 1.3 QD tables (above ground storage) (LEVEL 1)

NEQ (kg)	Quantity Distances (m)			
	D1	D2	D3	D4
500	25	60	60	60
600	25	60	60	60
700	25	60	60	60
800	25	60	60	60
900	25	60	60	62
1,000	25	60	60	64
1,200	25	60	60	69
1,400	25	60	60	72
1,600	25	60	60	75
1,800	25	60	60	78
2,000	25	60	60	81
2,500	25	60	60	87
3,000	25	60	62	93
3,500	25	60	65	98
4,000	25	60	68	105
5,000	25	60	73	110
6,000	25	60	78	120
7,000	25	62	82	125
8,000	25	64	86	130
9,000	25	67	89	135
10,000	25	68	92	140
12,000	25	74	98	150
14,000	27	78	105	155
16,000	28	81	110	165
18,000	30	84	115	170
20,000	32	87	120	175
25,000	35	94	125	190
30,000	39	100	135	200
35,000	42	105	140	210
40,000	44	110	150	220
50,000	50	120	160	240
60,000	54	130	170	255
70,000	59	135	180	265
80,000	63	140	185	280
90,000	66	145	195	290
100,000	70	150	200	300
120,000	77	160	215	320

NEQ (kg)	Quantity Distances (m)			
	D1	D2	D3	D4
140,000	83	170	225	335
160,000	88	175	235	350
180,000	94	185	245	365
200,000	99	190	250	375
250,000	110	205	270	405
Distance Functions				
	$0.22Q^{1/2}$	$3.2Q^{1/3}$	$4.3Q^{1/3}$	$6.4Q^{1/3}$

Table L.1: QD Table for HD 1.3 (Above Ground Storage)

Annex M
(normative)
Hazard division QD matrix (underground storage) (LEVEL 2)

The number of variables that impact on an explosive event within underground storage means that it is not possible to provide a single matrix relating PES to ES. Instead a range of QD coefficient factors are summarised or explained in Table M.1.

Factor	QD	QD Function / Formula	Remarks
Propagation by Rock Spall (Hard Rock) D_{cd} (Loading Density < 270kg/m^3)	D1[25]	**$0.6Q^{1/3}$**	A minimum of 5m shall be applied.
Major Damage Prevention by Rock Spall (Hard Rock) D_{cd} (Loading Density < 50kg/m^3)	D2	**$1.0Q^{1/3}$**	A minimum of 5m shall be applied.
Major Damage Prevention by Rock Spall (Sandstone) D_{cd}	D3	**$1.4Q^{1/3}$**	A minimum of 5m shall be applied.
Major Damage Prevention by Rock Spall (Limestone) D_{cd}	D4	**$1.7Q^{1/3}$**	A minimum of 5m shall be applied.
Major Damage Prevention by Rock Spall (Hard Rock) D_{cd} (Loading Density > 50kg/m^3)	D5	**$2.0Q^{1/3}$**	A minimum of 5m shall be applied.
Propagation by Flames and Hot Gases through Cracks and Fissures	CID	**$0.3Q^{1/3}$ to $2.0Q^{1/3}$**	The Q factor should be determined by geological survey. Unlikely to propagate if the CID is greater than 2.0 $Q^{1/3}$.
Blast from Tunnel Entrance[26] [27]	IBD PTRD[28]	**$D = 77 \times H_D \times LD^{1/3}$**	Where: H_D = Hydraulic Diameter of Tunnel Mouth $LD^{1/3}$ = Loading Density (kg/m^3)
		$H_D = 4A/C$	Where: A = Cross-sectional Area of Tunnel Entrance (m^2) C = Circumference of Tunnel Entrance (m)
		$LD^{1/3} = \frac{NEQ}{(V_{Ch} + V_{Tunnel})}$	V_{Ch}= Chamber Volume (m^3) V_{Tunnel} = Tunnel Volume (m^3)
Blast from Tunnel Entrance [50] [51]	APBD	**$D = 27.4 \times H_D \times LD^{1/3}$**	As above
Blast Effects from Surface Crater	IBD PTRD	**$22.2Q^{1/3}$**	Where the cover thickness is <$0.1Q^{1/3}$.
		$11.1Q^{1/3}$	Where the cover thickness is >$0.1Q^{1/3}$ but <$0.2Q^{1/3}$.
		$5.6Q^{1/3}$	Where the cover thickness is >$0.2Q^{1/3}$ but <$0.3Q^{1/3}$.
		Nil	Where the cover thickness is >$0.3Q^{1/3}$, as the effects will be negligible.
Ground Shock (Sand, Gravel, Wet Clay) *(Where the maximum particle velocity is 60mm/s)*	IBD PTRD	**$0.9\ f_d\ Q^{4/9}$**	Where: f_d = Decoupling Factor from Graph M.1. The PTRD is 2/3 IBD.
Ground Shock (Sandstone, Soft Rock) *(Where the maximum particle velocity is 115mm/s)*		**$4.8\ f_d\ Q^{4/9}$**	

[25] This may be reduced to as low as $0.3Q^{1/3}$ if the acceptor chamber has protective construction to prevent spall and collapse.

[26] The distance in a non-axial direction may be reduced using a multiplication factor (MF), which should be derived from the formula $MF = 1 / (1 + (\theta/56)^2)^{0.76}$, where θ is the angle from the tunnel centre line in degrees.

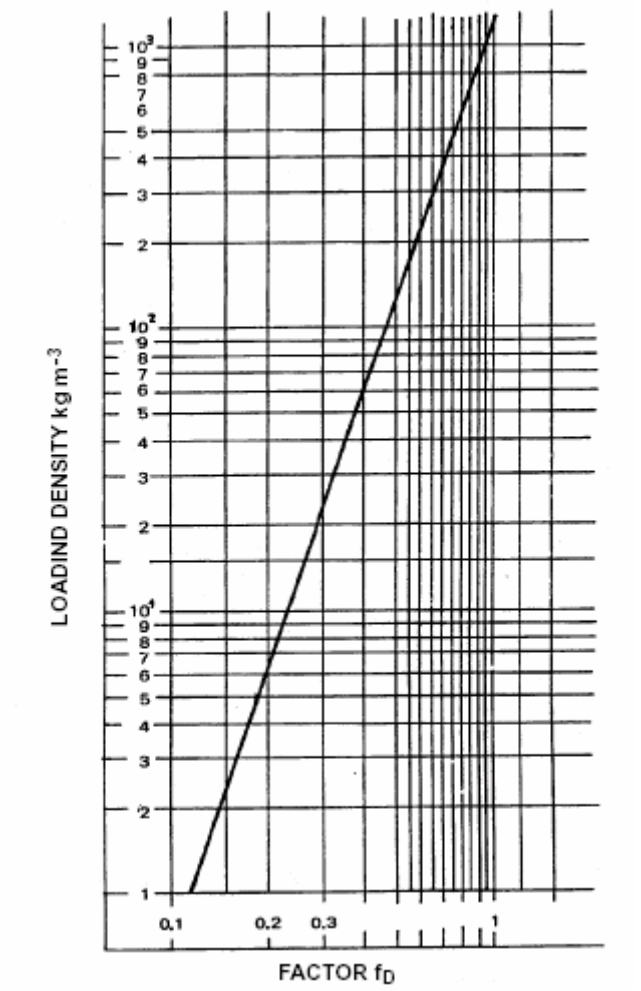
[27] This is a simple approximation. A more accurate methodology is in AASTP-1, Part 3, Clause 3.3.4.1 (b) and (c).

[28] For minor routes 2/3 of the IBD may be used in all cases.

Factor	QD	QD Function / Formula	Remarks
Ground Shock (Sand, Gravel, Wet Clay) *(Where the maximum particle velocity is 60mm/s*)		**$5.4\ f_d\ Q^{4/9}$**	
Debris Effects from Tunnel Entrance[29]	IBD PTRD	**600m**	For an arc of 10^0 either side of the centre line of the tunnel. Ideally all ES should be outside an arc of 30^0 either side of the centre line of the tunnel in order to enhance safety. Fragment/debris IBD can be reduced significantly with the addition of a proper barricade that eliminates line-of-sight out the tunnel entrance. Hence this distance may be reduced. The IBD / PTRD should be at that distance where fragment density is assessed as 'one hazardous fragment (energy greater than 79J) per $56m^2$.
Debris from Failure of Cover (Surface Crater Debris) (Hard Rock) *Limitations:* *NEQ from 1000kg to 2,000,000kg* *γ from 1kg/m^3 to 300kg/m^3* *$f_C > 0.1m/kg^{1/3}$*	IBD	**$38.7\ Q^{1/3}\ \gamma\ f_C\ f\alpha$**	If the scaled cover depth ($C/Q^{1/3}$) is greater than 1.2 then debris throw may be neglected. Where: γ = Loading Density (NEQ (kg)/Chamber Volume) C = Cover Depth (m) f_C = Scaled Cover Depth $(0.45+(2.15*C/NEQ^{1/3})-(2.11*(C/NEQ^{1/3})^2)$ $f\alpha$ = Overburden Slope Angle See Tables N.2 and N.3 for calculated overburden slope angle.
Debris from Failure of Cover (Surface Crater Debris) (Soft Rock) *(Limitations as above)*	IBD	**$1.15 * 38.7\ Q^{1/3}\ \gamma\ f_C\ f\alpha$**	See above

Table M.1: QD factors matrix for HD 1.1 (Underground Storage)

[29] This is a simple approximation. A more accurate methodology is in AASTP-1, Part 3, Clause 3.3.4.2.



Graph M.1: Ground shock decoupling factor (Underground Storage)

Annex N
(normative)
Hazard division QD tables (underground storage)[30] (LEVEL 2)

N.1 Chamber interval distance (CID) (HD 1.1)

NEQ (kg)	Chamber Interval Distance (m)				
	D1	D2 (Hard Rock) (<50kg/m^3)	D3 (Sandstone)	D4 (Limestone)	D5 (Hard Rock) (>50kg/m^3)
1,000	6.0	10.0	14	17	20
1,200	6.4	10.6	15	18	21
1,400	6.7	11.2	16	19	22
1,600	7.0	11.7	16	20	23
1,800	7.3	12.2	17	21	24
2,000	7.6	12.6	18	21	25
2,500	8.1	13.6	19	23	27
3,000	8.7	14.4	20	25	29
3,500	9.1	15.2	21	26	30
4,000	9.5	15.9	22	27	32
5,000	10.3	17.1	24	29	34
6,000	10.9	18.2	25	31	36
7,000	11.5	19.1	27	33	38
8,000	12.0	20.0	28	34	40
9,000	12.5	20.8	29	35	42
10,000	12.9	21.5	30	37	43
12,000	13.7	22.9	32	39	46
14,000	14.5	24.1	34	41	48
16,000	15.1	25.2	35	43	50
18,000	15.7	26.2	37	45	52
20,000	16.3	27.1	38	46	54
25,000	17.5	29.2	41	50	58
30,000	18.6	31.1	44	53	62
35,000	19.6	32.7	46	56	65
40,000	20.5	34.2	48	58	68
50,000	22.1	36.8	52	63	74
60,000	23.5	39.1	55	67	78
70,000	24.7	41.2	58	70	82
80,000	25.9	43.1	60	73	86
90,000	26.9	44.8	63	76	90
100,000	28.0	46.4	65	79	93
120,000	30.0	49.3	69	84	99
140,000	31.0	51.9	73	88	104
160,000	33.0	54.3	76	92	109

[30] For crater debris throw.

NEQ (kg)	Chamber Interval Distance (m)				
	D1	D2 (Hard Rock) (<50kg/m^3)	D3 (Sandstone)	D4 (Limestone)	D5 (Hard Rock) (>50kg/m^3)
180,000	34.0	56.5	79	96	113
200,000	35.0	58.5	82	99	117
250,000	38.0	63.0	88	107	126
300,000	40.0	66.9	94	114	134
350,000	42.0	70.5	99	120	141
400,000	44.0	73.7	103	125	147
500,000	48.0	79.4	111	135	159
Distance Functions					
	$0.6Q^{1/3}$	$1.0Q^{1/3}$	$1.4Q^{1/3}$	$1.7Q^{1/3}$	$2.0Q^{1/3}$

Table N.1: CID Table for HD 1.1 (Underground Storage)

N.2 Crater debris throw (overburden slope angle - increasing)

α (^{0})	fα
0.0	1.00
2.5	1.05
5.0	1.10
7.5	1.15
10.0	1.20
12.5	1.25
15.0	1.30
17.5	1.35
20.0	1.40
22.5	1.45
> 25.0	1.50

Table N.2: Crater debris throw (overburden slope angle – increasing)

N.3 Crater debris throw (overburden slope angle - decreasing)

α (^{0})	fα
0.0	1.00
2.5	0.94
5.0	0.88
7.5	0.81
10.0	0.75
12.5	0.69
15.0	0.63
17.5	0.56
20.0	0.50
22.5	0.44
25.0	0.38
27.5	0.31
> 30.0	0.25

Table N.3: Crater debris throw (overburden slope angle – decreasing)

Annex P
(normative)
Hazard division QD matrix (ports) (LEVEL 2)

The number of variables that impact on an explosive event within port and vessel storage means that it is not possible to provide a single matrix relating PES to ES. Instead a range of QD coefficient factors are summarised or explained in Table P.1.

Factor	QD	QD Function / Formula	Remarks
Process Buildings (Land)	PBD	**As per Annexes E, G and L as appropriate**	
Inhabited Buildings (Land)	IBD	**$16.7Q^{1/3}$**	If a high density population then $22.2Q^{1/3}$ should be applied.
Vulnerable Buildings (Land)	VBD	**$33.3Q^{1/3}$**	If a vulnerable building falls within this distance an ECA should be completed.
Public Traffic Route Low Density	PTRD	**$16.7Q^{1/3}$**	
Public Traffic Route Medium Density		**$11.1Q^{1/3}$**	
Public Traffic Route High Density		**$8.0Q^{1/3}$**	
Military personnel in open not working with the explosive shipment.		**$11.1Q^{1/3}$**	
Bulk Above Ground Petroleum, Oil and Lubricant (POL) Storage Areas		**$11.1Q^{1/3}$**	
Canteens (<50 persons)		**$11.1Q^{1/3}$**	
Canteens (>50 persons)		**$16.7Q^{1/3}$**	
Passenger Terminals and Ships during Embarking and Disembarking		**$22.2Q^{1/3}$**	When explosives are being loaded or unloaded.
		$16.7Q^{1/3}$	During normal storage.
POL Tanker Vessels		**$16.7Q^{1/3}$**	No unloading or loading operations on either ship.
		$22.2Q^{1/3}$	During concurrent loading or unloading operations.
		$16.7Q^{1/3}$	During single ship unloading or unloading operations.
Bulk Carrier Vessels (Other dangerous Goods)		**$11.1Q^{1/3}$**	
Port Operating Facilities		**$11.1Q^{1/3}$**	
Transit Storage for Dangerous Goods		**$16.7Q^{1/3}$**	
Onboard Barricades	IMD	**$0.8Q^{1/3}$**	This must equate in robustness to the level of protection afforded by an Earth Barricade of 2.4m.
Normal Protection Level (Barricaded)	SD2	**$4.8Q^{1/3}$**	For HD 1.1 Between vessels each carrying explosives only.
Normal Protection Level (Un-barricaded)	SD3	**$8.0Q^{1/3}$**	For HD 1.1 Between vessels each carrying explosives only.
Reduced Protection Level (Barricaded)	SD1	**$3.2Q^{1/3}$**	For HD 1.1 Between vessels each carrying explosives only.
Reduced Protection Level (Un-barricaded)	SD2	**$4.8Q^{1/3}$**	For HD 1.1 Between vessels each carrying explosives only.
Normal Protection Level (Unbarricaded-)	SD4	**$16.0Q^{1/3}$**	For HD 1.1 From manned vessels loading or unloading explosives.
Normal Protection Level (Barricaded)	SD3	**$8.0Q^{1/3}$**	For HD 1.1 From manned vessels, with effective internal barricaded, loading or unloading explosives. From unmanned vessels (i.e. barges) loading or unloading explosives.

Table P.1: QD factors matrix for HD 1.1 (Port Storage)

Annex Q
(normative)
Hazard division QD tables (ports) (LEVEL 2)

Q.1 Quantity distances (HD 1.1) between vessels each carrying explosives.

NEQ (kg)	Quantity Distances to other Vessels (Ships Distance (SD)) (m)			
	SD1	SD2	SD3	SD4
500	60	39	135	135
600	60	41	135	135
700	60	43	135	145
800	60	45	135	150
900	60	47	135	155
1,000	60	48	135	160
1,200	60	52	135	175
1,400	60	54	135	180
1,600	60	57	135	190
1,800	60	59	135	195
2,000	60	61	135	205
2,500	60	66	135	220
3,000	60	70	135	235
3,500	60	73	135	245
4,000	60	77	135	255
5,000	60	83	140	275
6,000	60	88	150	295
7,000	62	92	155	310
8,000	64	96	160	320
9,000	67	100	170	335
10,000	69	105	175	345
12,000	74	110	185	370
14,000	78	120	195	390
16,000	81	125	203	404
18,000	84	130	210	420
20,000	87	135	218	435
25,000	94	145	235	470
30,000	100	150	250	500
35,000	105	160	265	530
40,000	110	165	275	550
50,000	120	180	295	590
60,000	130	190	315	630
70,000	135	200	330	660
80,000	140	210	345	690

NEQ (kg)	Quantity Distances to other Vessels (Ships Distance (SD)) (m)			
	SD1	SD2	SD3	SD4
90,000	145	220	360	720
100,000	150	225	375	750
130,000	160	245	395	790
140,000	170	250	420	840
160,000	175	265	435	870
180,000	185	275	455	910
200,000	190	285	470	940
250,000	205	305	510	1,020
300,000	215	325	540	1,080
350,000	230	340	570	1,140
400,000	240	355	590	1,180
500,000	255	380	640	1,280
1,000,000	320	480	800	1,600
Distance Functions				
	$3.2Q^{1/3}$	**$4.8Q^{1/3}$**	**$8.0Q^{1/3}$**	**$16.0Q^{1/3}$**

Table Q.1: QD Table for HD 1.1 (Ports)

Q.2 Quantity distances (HD 1.2) between vessels each carrying explosives.

For HD 1.2 fixed separation distances should be applied as follows:

a) SsD 1.2.1 - 60m; and

b) SsD 1.2.2 - 30m.

For HD 1.3 a fixed separation distance of 60m should be applied under all conditions.

For HD 1.4 a fixed separation distance of 25m should be applied under all conditions.

Q.3 Quantity and separation distances between manned vessels loading or unloading explosives.

For HD 1.1, SD4 as per Tables P.1 and Q.1.

For HD 1.2 fixed separation distances should be applied as follows:

c) SsD 1.2.1 - 90m; and

d) SsD 1.2.2 - 60m.

For HD 1.3 a fixed separation distance of 60m should be applied under all conditions.

For HD 1.4 a fixed separation distance of 25m should be applied under all conditions.

Q.4 Quantity and separation distances between barricaded manned vessels or un-barricaded unmanned vessels loading or unloading explosives.

For HD 1.1, SD 3 as per Tables P.1 and Q.1.

For HD 1.2 fixed separation distances should be applied as follows:

e) SsD 1.2.1 - 90m; and

f) SsD 1.2.2 - 60m.

For HD 1.3 a fixed separation distance of 60m should be applied under all conditions.

For HD 1.4 a fixed separation distance of 25m should be applied under all conditions.

Amendment record

Management of IATG amendments

The IATG are subject to formal review on a five-yearly basis. This does not preclude amendments being made within these five-year periods for reasons of operational safety, efficacy and efficiency or for editorial purposes.

As amendments are made to this IATG module they will be given a number, and the date and general details of the amendment will be shown in the table below. The amendment will also be shown on the cover page of the IATG by the inclusion of the amendment number and date.

As the formal reviews of each the IATG module is completed, new editions will be issued. Amendments will be incorporated into the new edition and the amendment record table cleared. Recording of amendments will then start again until a further review is carried out.

The most recently amended, and thus extant, IATG module is posted on www.un.org/disarmament/ammunition

Number	Date	Amendment Details
0	01 Feb 15	Release of Edition 2 of IATG.
1	31 March 21	Release of Edition 3 of IATG.