



SAFETY SERVICES ORGANISATION



Session 3.3

Separation and Quantity Distances

**IATG Foundation Course:
Ammunition Storage Infrastructure Module**



Lesson Objectives

At the end of this lesson you should be able to:

- Identify the aggregated hazards and risks of explosives.
- Have an understanding of how distance may be used to mitigate the effects of explosions.
- Understand the key concepts and terminology associated with ammunition and explosives facilities.
- Have knowledge of the factors affecting safe storage of ammunition and explosives.
- Explain the rules for application of QDs.



Theory of Separation and Quantity Distances

- Separation distances between a stock of explosives and a site at risk from an explosion are used to reduce the level of risk to a tolerable level.
- Unplanned explosions may be mitigated by regulating the quantity of explosives in a given location and the distances to adjacent ammunition storage locations.
- Separation distances and QDs: note that separation distances may be based upon consequence analysis or QD tables.
- QDs (tables) are mathematical calculations which underpin the theory of separation and QD.

Definitions

- **Potential Explosion Site (PES):**

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 to an exposed site (ES).

- **Exposed Site (ES)**

a magazine, cell, stack, truck or trailer loaded with ammunition, explosives workshop, inhabited building, assembly place or public traffic route, which is exposed to the effects of an explosion (or fire) at the potential explosion site (PES) under consideration.

- **QD**

the minimum permissible distance required between a potential explosion site (PES) and an exposed site (ES).

QDs are sub-divided into:

- **IQD** - *the minimum permissible distance between a potential explosion site (PES) and an exposed site (ES) inside the explosives area.*
- **OQD** - *refers to the minimum permissible distance between a potential explosion site (PES) and an exposed site (ES) outside the explosives area.*



Definitions

- **Subdivisions of QDs - IQD:**

- **Inter-Magazine Distance (IMD)** *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.*
- **Process Building Distance (PBD)** *the minimum permissible distance from a building or stack containing explosives to a process building, or from a process building to another process building, which will provide a reasonable degree of immunity for the operatives within the process building(s), and a high degree of protection against immediate or subsequent propagation of explosions*



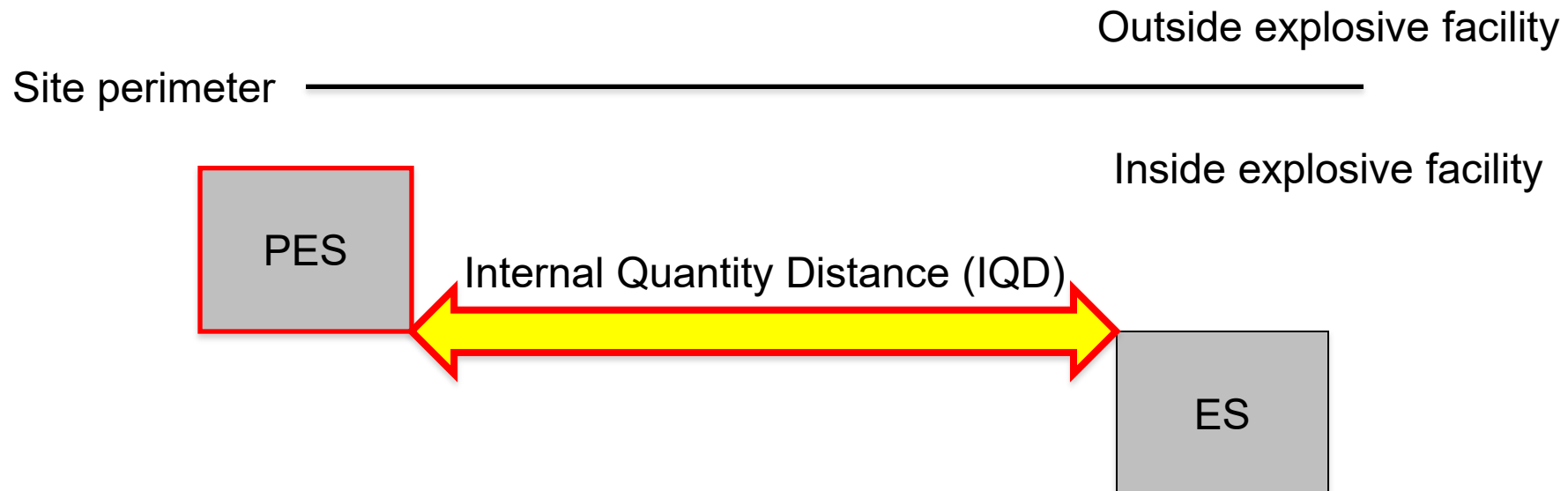
Definitions

- **Subdivisions of QDs - OQD:**

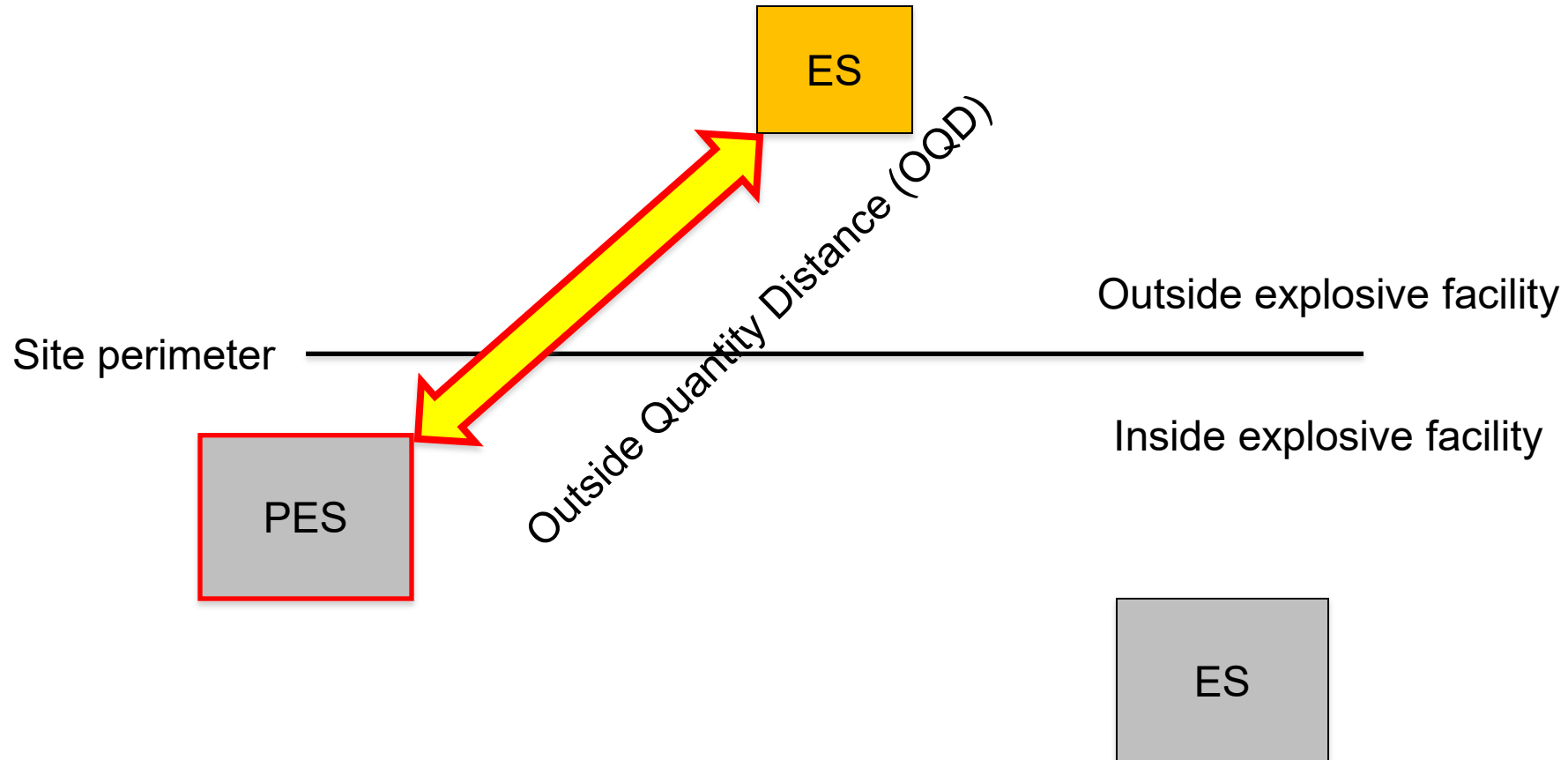
- **Inhabited Building Distance (IBD)** *the minimum permissible distance between potential explosive sites (PES) and non-associated exposed sites (ES) that requires a high degree of protection from an explosion.*
- **Public Traffic Route Distance (PTRD)** *the minimum permissible distance between a 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).*
- **Vulnerable Building Distance (VBD)** *the minimum permissible distance between a potential explosion site (PES) and a vulnerable building.*



Inside Quantity Distances



Outside Quantity Distances



Types of Outside Quantity Distances

Inhabited Building Distance (IBD):

- PES to sites where the general public, or workers not directly associated with the explosive facility, live, work or congregate
- Intended to prevent serious structural damage to ‘traditional’ types of building
- No direct injury to people in the open from blast/heat
- Some injury possible from fragmentation



Types of Outside Quantity Distances

- **Vulnerable Building Distance (VBD):**
 - Used for an inhabited building which is of ‘vulnerable construction’, such as a glass façade
 - A large facility of special importance, such as a school or hospital
- Normally twice the distance of the IBD



Types of Outside Quantity Distances

- **Public Traffic Route Distance (PTRD):**
 - Roads and railways
 - Waterways, including rivers, canals and lakes
 - Airport buildings and facilities (unless ‘vulnerable’)
 - Public rights of way (e.g. footpaths)

Density	Appropriate QD
High Density Usage	100% of IBD
Medium Density Usage (the PTRD)	67% of IBD
Low Density Usage	50% of IBD

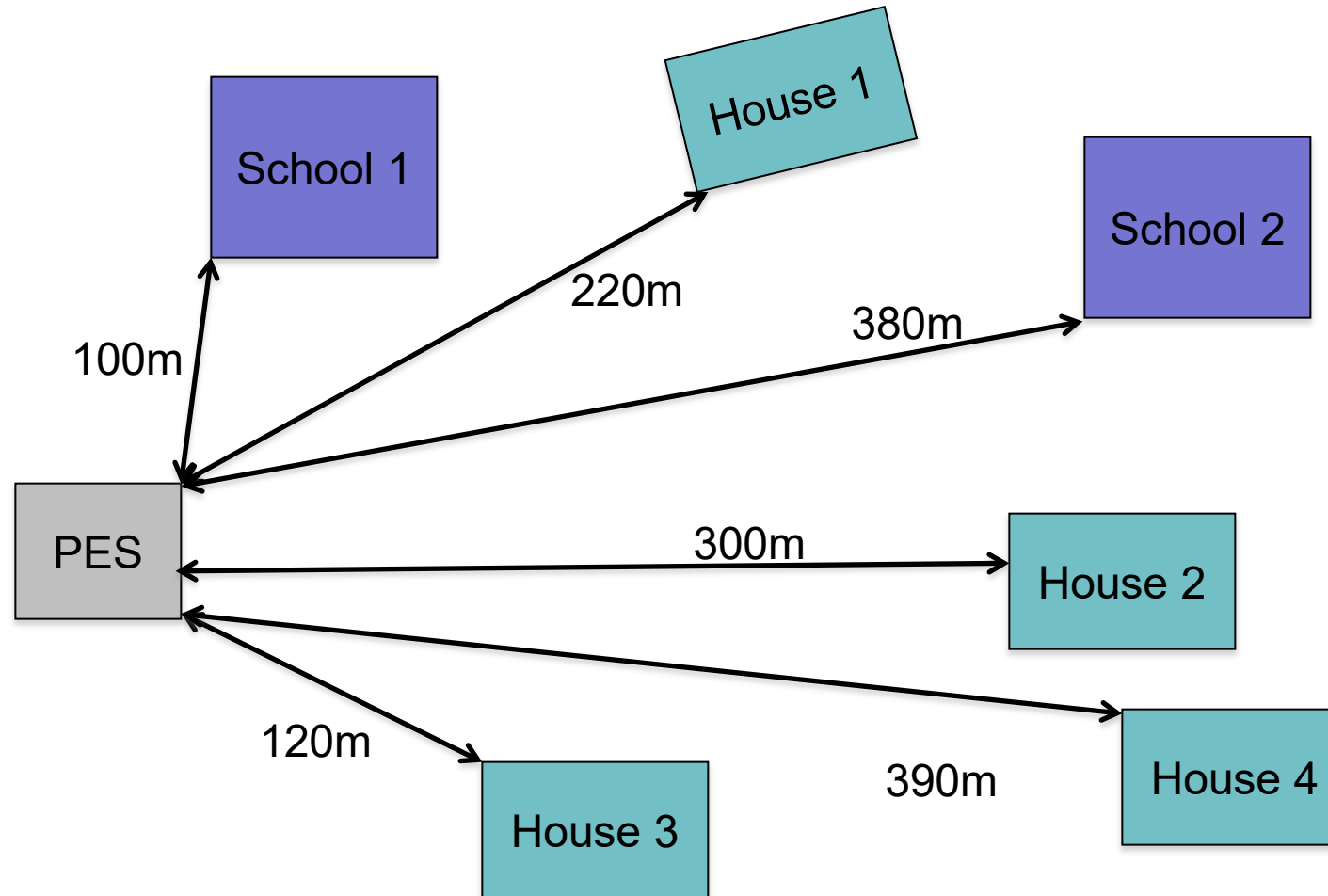


Factors Affecting QDs

- **Risk in ammunition storage may be reduced by altering procedural and/or infrastructure factors as follows:**
 - NEQ and the type, sensitiveness and packaging of the explosives
 - HD sub division for storage
 - Method of construction and orientation of PES and the ES
 - The use of traverses
 - The degree of protection required
 - Adequacy of evacuation arrangements



Measurement of Quantity Distances



Rationale for different types of QD for different categories of ES

- QDs are based on trials, experimentation, modelling and analysis of real events.
- For a small NEQ, with little duration, the threat to structures is significantly less than from a very large NEQ event
 - Blast - Introduce Kingery & Bulmash
 - Fragmentation – Gurney
- QD factors were initially developed for these very large NEQ events and then scaled down to apply for smaller quantities



Unitisation

- **Highly complex issue**
 - Be aware of it though
- **Use of amended Quantity Distances possible**
- **Seek specialist ammunition technical advice**



Aggregation of Net Explosive Quantity (NEQ)

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.



Aggregation of Hazard Divisions 1.4, 1.5 and 1.6

HD 1.4: Separation distances based on fire risks

HD 1.5: Treat as 1.1 for flexibility

HD 1.6: See NATO Publication AASPT-1



Rules for the use of QDs

- There are principal rules that must be applied for QD to be effective in reducing risk in ammunition storage facilities.
- The rules are for Above Ground Storage; note there are differences for:
 - Underground Storage – due to geology, channelling of blast etc
 - Ports – due to different effects on vessels from blast being attenuated by water



Determination of QD or permissible quantities

- Risk of explosives incidents can be reduced between a PES and another PES or ES, (containing the same type of HD), by sub-dividing the NEQ so that the smaller quantities cannot produce an instantaneous explosion in adjacent stacks
- **This is determined by:**
 - Consider each building or stack, in turn, as a PES
 - Refer to the table of each HD that can be stored in the building or stack considered as a PES
 - Determine the QD for each HD as the minimum to be required from the building or stack
 - Record the QD in terms of each HD in each instance as those to be required from the building or stack. Or, calculate the NEQ of each HD based upon the distances

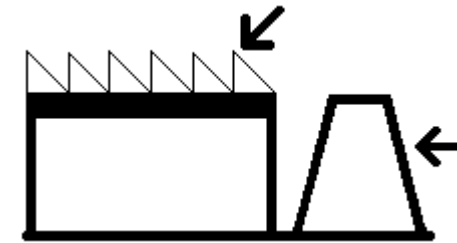


The Explosive Limit License (ELL) - Background

- Each PES will be licensed - therefore each PES has an ELL
- The ELL states maximum NEQ to be stored in a given PES
- The ELL has a table to show how the limits were derived
- The table uses ‘pictograms’ to denote different types of structure, and the Quantity Distance between each type



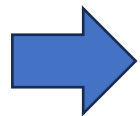
Pictograms

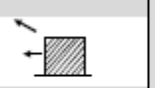
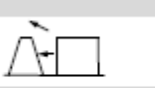
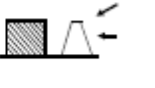
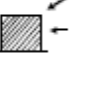
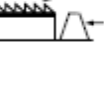
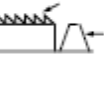


QD Tables - Matrices



IATG 02.20 Annex D



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



QD Tables – NEQ Limits by HD and Distance

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

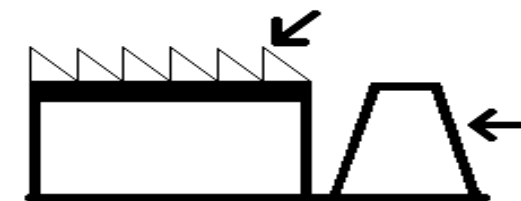
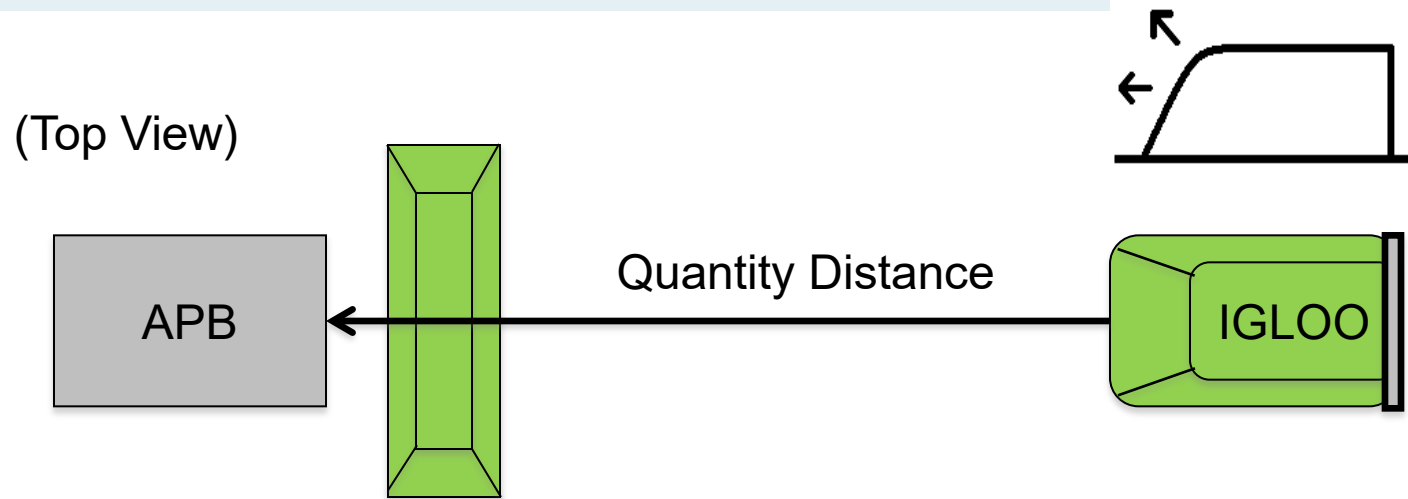
IATG 02.20 Annex E

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



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Worked Example



(Pictograms)

