



SAFETY SERVICES ORGANISATION



Session 3.1

Types of Ammunition Storage Facility

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



Lesson Objectives

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

- Describe the different types of Ammunition Storage Facility
- Identify different types of building and infrastructure that may be encountered
- Identify appropriate infrastructure that is fit for purpose

Effects of Explosions on Buildings

- **Understand the principal effects of an explosive event:**
 - Fragmentation & Debris
 - Fire & Thermal radiation
 - Ground Shock
 - Blast
- **What are the explosive effects are applicable to each Hazard Division, including physiological effects?**
- **Understand how these effects impact upon buildings and how protection from the effects may be enhanced**

Fragmentation Effects

- **Fragments from OME casing and packaging**
 - Velocity iro 3000m/s
 - Death & injury
 - Initiation of OME
- **Range > IBD (1% probability of hitting person with 1 fragment 80 joules in area of 56m²)**

Debris Effects

- **Debris from structural materials**
 - Velocity iro 10 – 500m/s
 - Death & injury
 - Initiation of OME
 - Directional
 - Crater
- **Range > IBD (1% probability of hitting person with 1 fragment 80 joules in area of 56m²)**



Fire & Thermal Radiation

- **Detonation (HD1.1)**

- Short-lived fireball (milliseconds)
- Negligible effect compared to blast and fragmentation

- **Burning (HD1.3)**

- Energy release comparable to HD1.1 but duration of seconds
- Flame
- Thermal radiation

- **Burning inside structure**

- Combustion gas pressure
- Breaching/bursting
- Lower velocity debris



Ground Shock

- **Detonation on or near ground**
 - Shock loading of ground surface
 - Energy transmitted to air -> air-induced ground shock
- **Factors:**
 - Soil/Rock type
 - Air temperature & density
 - Distance from seat of detonation
- **Above ground storage**
 - Effects considered small relative to air blast
- **Underground storage**
 - Effects and consequences are significant



Blast

- **Supersonic shock front expanding radially**
 - +ve particle (wind) velocity
 - Dynamic pressure on objects
- **Higher pressure on impact due to reflection**
- **Over time & distance:**
 - Strength decays
 - Duration increases
 - Velocity decreases
- **Negative phase**

Blast

Quantity Distance (m) (Q =NEQ in kg)	Peak Incident (Side-on) Overpressure Expected (kPa)
$44.4Q^{1/3}$	2
$22.2Q^{1/3}$	5
$14.8Q^{1/3}$	9
$8.0Q^{1/3}$	21
$3.4Q^{1/3}$	80
$2.4Q^{1/3}$	180

Table 1: Blast overpressure from a bare charge or light structure

Impulse

- **Function of peak pressure and load duration**
 - Higher NEQ produces higher pressures of longer duration
- **Example:**
 - 5kPa incident overpressure from 5kg detonation → 23.3Pa-s
 - 5kPa incident overpressure from 50,000kg detonation → 501 Pa-s
- **Determines the adequacy of a structure to protect inhabitants**

Practicalities

- **Most explosives insensitive to direct blast overpressure**
- **Blast overpressure + structural motion**
- **Direct insult by low-angle, high-velocity fragments**
- **Primary design objectives:**
 - Prevent significant deformation of ES structures
 - Prevent fragment/debris penetration
 - Prevent spalling from internal faces
- **Likely projections hazard at all scaled distances $< VBD$**

Protection against explosive propagation

- **Adequate separation distances**
- **Building designed to protect contents from explosion effects**
 - Strong enough to withstand force of explosion; or
 - Light enough so collapse or debris will not initiate contents
- **Traverses**
 - To stop high-velocity, low-angle fragments/debris

Considering HD 1.1

- **Open stacks:**
 - QD
 - Traverses
- **Compartmentalised storage**
 - To reduce Maximum Credible Event (MCE)
 - Delay/prevent prompt propagation
- **Reinforced concrete and earth covered structures**
 - Designed to protect against most extreme blast hazard
- **Masonry, unreinforced concrete, timber, steel, etc**
 - Reduced resistance to external blast loading
 - Significant structural debris threat to surrounding ES



Considering HD 1.2

- **Concrete, brick, earth covered structures suitable**
 - Reduces utility for HD1.1
 - No use of timber or lightweight steel doors
- **Progressive series of small explosions and fragments or lobbed munitions which subsequently explode**
- **Empirical data might benefit selection of QD**

Considering HD 1.3

- **Thermal radiation effects on adjacent ESH**
- **Fireball**
- **Intense radiant heat**
- **Firebrands**
- **Wind effect can increase flame radius by 50%**
- **Weak points in PES structure may cause flame jetting**
- **Combustion products causing pressure inside structure – burst/breach**



Considering HD 1.4, 1.5 and 1.6

- **1.4 – any secure, weatherproof structure**
- **1.5 – treat as 1.1**
- **1.6 – seek technical detail and treat as 1.1 or 1.2**
 - May require specific security measures

Types of Buildings and Infrastructure

- **Examples of various types of storage infrastructure are:**
 - Open bay/stack
 - Containers or light structures
 - Medium- or Heavy-Walled buildings
 - Earth covered buildings, including “Igloo” construction
- **Additional infrastructure requirements include:**
 - Process Buildings
 - Offices
 - Other non-explosives stores/workshops; etc.
- **It is important to match the type of building with the type of ammunition to be stored; national economic and resource capacity; and degree of protection to be provided to local population**

Light structured buildings

- **Light , frangible materials**
 - Few dangerous projections as PES
 - Collapse/debris should not initiate explosives as ES
- **Little resistance to high velocity fragments or lobbed ammunition from HD 1.1 or 1.2 event**
- **Little resistance to fire from 1.3 event**
- **Traverses to reduce QD:**
 - Optional for use as ESH
 - Mandatory for use as PB



Light structured buildings



Source: seabox.com

Medium walled building

- **Walls:**
 - 215mm solid masonry
 - 280mm cavity masonry
 - 150mm reinforced concrete
- **Roof:**
 - 150mm RC slab
- **Doors:**
 - 16mm mild steel plate
- **Debris may initiate explosives or seriously injure people**
- **Will NOT resist penetration by high-velocity fragments**
- **Reasonable protection from 1.2 projections**
- **Adequate protection from 1.3 fire hazard**



Medium walled building



Source: DSTL Fort Halstead

Heavy walled building

- **Walls:**

- 680mm solid masonry
- 450mm reinforced concrete

- **Roof:**

- Minimum 150mm RC slab

- **Doors:**

- 50mm mild steel plate

- **Traverse if stocks vulnerable to debris**

- **Will prevent initiation of explosives by fragments**

- **Will resist 1.2 projections**

- **Adequate protection from 1.3 fire hazard**

- **As PES:**

- Intercepts most high-velocity fragments
- High volume of debris



Earth covered magazine

- **Walls and Roof:**

- Reinforced concrete box
- Steel and RC box
- 600mm minimum earth cover

- **Doors and headwall:**

- Designed to resist blast loading (5bar or 7bar typical) and high velocity fragment penetration

- **As a PES:**

- Reduced QDs to side and rear
- Blast and fragmentation hazard mainly to front
- Orientation



Earth covered magazine



Earth covered building

- **Walls and Roof:**

- Any structure
- 600mm minimum earth cover

- **Doors:**

- 16mm mild steel plate

- **As a PES:**

- Traverse to shield doors and walls that are not earth-covered

- **As an ES:**

- Will prevent initiation of explosives by fragments
- Will resist 1.2 projections
- Adequate protection from 1.3 fire hazard



Earth covered building



Process building

- **Walls, Roof and Doors:**

- Any suitable structure

- **As a PES:**

- Classify according to construction
- QDs based on total NEQ present unless effectively unitised
- Apply ALARP for protection of workers

- **As an ES:**

- Designed to survive and protect workers; or
- Large separation distance to protect workers, not just to protect against initiation of explosives



Process building



APB at 3 Base Ammunition Depot, Bracht, Germany 1970s

Inhabited buildings and PES

- **Walls, Roof and Doors:**

- Glazing is vulnerable to effects of blast

- **As an ES:**

- Non-explosives inhabited buildings within IBD should be designed to resist expected overpressure, fragments and debris
- Single- or double-glazing acceptable
- Laminated glass or anti-shatter film permitted



Questions?

Lesson Objectives

You should now be able to:

- Describe and understand the main considerations for siting an Ammunition Storage Facility
- Describe the different types of Ammunition Storage Facility
- Identify different types of building and infrastructure that may be encountered
- Identify appropriate infrastructure that is fit for purpose



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Siting and Planning

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



Lesson Objectives

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

- Describe and understand the main considerations for siting an Ammunition Storage Facility

Siting Considerations

- Consideration must be given to siting explosives storage facilities to enable safe, economic and effective operations
- Distances to areas used by the general public must be sufficient to keep the level of risk to a minimum (ALARP) and an acceptable level of protection provided
- Minimise the potential for loss of ammunition stocks due to accidental or deliberate explosive events
- Provide an environment in which ammunition and explosives can be maintained in a fully serviceable condition

Quantity distances

- **Adequate QDs for stocks**
 - Special storage requirements
- **Best use of available area:**
 - 1.1 in centre...
 - 1.4 near perimeter
 - Minimum IMD > limited MCE
- **Traversing**
- **Balance costs of:**
 - Construction
 - Land
 - OME to be held

Location

- **Isolation**
- **Accessibility**
- **Storage capacity**
- **Handling capacity**
- **Communication**
- **Climate**
- **Terrain**

Isolation

- **PES to fence min 25/50m**
 - QDs
- **Encroachment within yellow line**
 - Safeguarding
- **Avoid power lines, water mains, gas and oil networks**
- **Not under airfield circuits**
- **Avoid radiation hazards e.g:**
 - Mobile telephone masts
 - Mobile and fixed radar
 - Mobile and fixed radio facilities
 - Television masts



Accessibility

- **Essential for:**

- Customers
- Suppliers
- Despatch by road/rail/ air/ sea
- Workforce

- **Internal traffic circuit**

- IN
- OUT
- Vehicles should not need to retrace their steps

Storage and handling capacity

- **Store expected quantity and types of ammunition**
- **Handle/process ammunition efficiently**

Communication – road and rail

- **External roads**

- Minimise hazard to public
- Width and strength for HGV
- Minimise impact of PTRD

- **Internal roads**

- One-way system
- Speed restrictions
- Cope with heaviest and longest HGV
- Gradients

- **Stabling area**

- **Rail**

- **Road link to railhead**

- **Rail direct into facility**

- Rail authority certification that public rail can handle traffic
- Shunting lines
- Turning facilities
- Marshalling area
- Road/Rail Transfer facility



Climate and Terrain

- **Electrical storms**
- **High winds**
- **High rainfall**
- **Well-drained**
- **Snow**
- **Humidity**
- **Firm, stable subsoil**
- **Thick woods**
- **Dry, gentle undulating land**
 - Natural traverses



Facilities within a depot

- **Explosives storehouses (ESH)**
- **Ammunition process buildings (APB)**
- **Administration buildings**
- **Non-explosive storage**
- **Stabling facility**
- **Lighting**
- **Firefighting**
- **Disposals facility**
- **Backup power**



Facilities within Ammunition Storage Areas

- Determine the types of facilities in a typical ammunition storage area and what are their purposes?
- Determine the considerations for establishing a new ammunition storage facility
- For smaller storage locations, decide which of these facilities may not be required
- **Understand and apply** the processes and procedures for approval of new explosives facilities or changes to existing facilities

Questions?



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