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Barricades

UN SaferGuard
Securing ammunition, protecting lives

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Warning

The International Ammunition Technical Guidelines (IATG) are subject to regular review and revision. This document is current with effect from the date shown on the cover page. To verify its status, users should consult www.un.org/disarmament/ammunition.

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Contents

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 warehouse detonations count among the heaviest explosions ever recorded.

Diversion from ammunition stockpiles has fuelled armed conflict, terrorism, organized 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] Finalized 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 '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 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 organizations 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

This IATG module details how barricades[3] may be used to intercept low angle, high velocity fragments from an explosive event on one side of the barricade to prevent the prompt initiation of explosives on the other side. Such fragments are the predominant threat leading to such an occurrence. Barricades can also protect personnel from low angle fragments, debris, and provide some protection at an Exposed Site (ES) from blast and flame. Correct design, construction and siting are essential in order to make effective use of the Quantity Distances (QDs) calculated.[4]

This IATG module only refers to barricades used in the design and construction of permanent explosive storage facilities.

Natural ground features may be used for this purpose, but the most common forms are artificial earth mounds, reinforced concrete and masonry walls, or a combination of these types. A barricade may be completely destroyed in an explosion, but its design should be such that it will stop or sufficiently slow down low angle, high velocity fragments before it collapses or is dispersed. If personnel protection is being afforded by a barricade, then its design will need to ensure that it does not present an additional hazard.

To be effective, a barricade shall be constructed of properly specified materials to a minimum effective thickness.

[3] The term 'traverse' is also used by some nations to describe a barricade.

[4] See IATG 02.20 *Quantity and separation distances*.

Barricades

1 Scope

This IATG module introduces different types of barricades, explains the function they perform and recommends how they should be sited and constructed.

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 *Glossary of terms, definitions and abbreviations,* shall apply.

The term 'national technical authority' refers to *the government department(s), organisation(s) or institution(s) charged with the regulation, management, co-ordination and operation of conventional ammunition storage and handling activities.*

The term ‘barricade’ refers to *a natural ground feature, artificial mound, or wall which is capable of intercepting high velocity low angle projections from a potential explosion site and preventing initiation of explosives stocks stored nearby.*

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 Barricades

A barricade is a barrier whose role is to intercept the low angle, high velocity fragments from an explosion. In doing so, it will prevent the initiation of explosives stored behind the barricade. Natural ground features may be used for this purpose, but in the event of this not being possible, then some construction will be necessary.

The most common barricades are earth mounds, reinforced concrete (RC) and masonry walls, or a combination of these types. A barricade may be completely destroyed in an explosion, but its design should enable it to stop or sufficiently slow down high velocity fragments before it collapses or is dispersed.

To be effective, a barricade must be constructed of properly specified materials to a minimum effective thickness. This IATG module will provide construction details and diagrams, which the national technical authority should modify in line with its own national regulations, but it is suggested that the module provided here should be the minimum required.

It should be noted that although barricades will also protect personnel from low angle, high velocity missiles and fragments, and can provide some protection at an Exposed Site (ES) from blast and flame, its primary function is the prevention of initiation of explosives by low angle, high velocity fragments, which are the predominant threat leading to such an occurrence.

A barricade is not considered to stop high angle fragments and debris, which travel over the barricade and are generally the basis for minimum inhabited building distances. However, for smaller quantities of net explosive quantity (NEQ), a building and barricade concept can be designed to reduce inhabited building distances. A full-scale test shall be conducted to validate the design.

5 Functional types of barricade (LEVEL 2)

Barricades may be divided into four functional areas and are defined by the type of protection provided. However, it is not always possible to distinguish clearly between barricade types because their functions change and merge according to their position relative to an ES or a Potential Explosion Site (PES). Yet classification by function is still useful because it indicates a measure of the barricade strength required.

The four types of barricade are:

a) A receptor barricade. This protects the explosives within the ES. It surrounds from direct attack by low angle, high velocity fragments and debris from an explosion in an adjacent PES. This type should be used for ES where the explosive quantities are too large for an interceptor barricade at the PES to be effective at a specified quantity distance , which cannot be changed. A receptor barricade should be as close as possible to the ES it is protecting;

b) An interceptor barricade. An interceptor barricade is positioned close to the PES and is designed to protect explosives at the ES from direct attack by low angle, high velocity fragments. The barricade may be undermined by the crater created by the explosion and destroyed by the blast loading. However, it must remain in position long enough to intercept and retard fragments before it collapses;

c) A container barricade. This type is designed to contain the high velocity fragments projected from an explosion within. It protects personnel and ES in the vicinity from the effects of an internal explosion. Therefore, it must remain substantially intact after an explosion. In real terms, a container barricade is only practical for small quantities of explosives (<1000 kg) and is only of value around process buildings or relatively small ammunition stacks; and

d) A screening barricade. As its name suggests, this is a barricade designed to act as a screen between a PES and an ES. It is designed to intercept fragmentation at a higher angle than is normal for a barricade. It may be situated at the ES but is usually more effective if situated at the PES. If it is located at a PES it should be high enough to intercept all fragments projected at 40° or less and remain substantially intact after an explosion. The 40° line shall be measured from the centre of the top of the explosives stack if the roof is lightweight and from the centre of the roof if it is not of lightweight construction.[5] The effects of potential blast overpressure loading should also be considered in the design phase to ensure that the barricade would not collapse on the structure it was protecting.

6 Location of barricades (LEVEL 2)

The barricade should be as close as possible to either the PES or the ES, depending on its purpose. The barricade toe or face should be a minimum of 1m from the stack of explosives or wall of any building it protects. However, access for stock, mechanical handling equipment (MHE), building maintenance etc may require a greater distance. This may in turn require a larger barricade.

Where a barricade may be undermined by the potential crater, or the NEQ exceeds 75,000kg of Hazard Division (HD) 1.1, the barricade should be moved outwards to avoid undermining. As an alternative, the thickness of the barricade may be increased in proportion to the quantity of explosives so that at least 2/3 of its base is outside of the potential crater. The approximate crater diameter (D) in metres is given by the formula $D = Q^{1/3}$ where Q is the NEQ in kg.

For a more accurate prediction of crater size, particularly where undermining may occur, appropriate design methods shall be employed. These take into consideration the depth of burst, the soil or other material type in which the crater is formed including any concrete slab effects. Specialist ammunition technical advice should be sought.

7 Barricade materials (LEVEL 2)

An explosion may disperse the material used for a barricade, especially if it is vertically or near vertically faced. The resulting debris hazard may initiate explosives in adjacent buildings and present a hazard to personnel. In order to minimise these effects, materials to one of the specifications in Table 1 should be used in the construction. The materials are listed in order of preference.

The stability of the barricade slope should be checked on a case by case basis. The required factor of safety against rotational slip will depend on: 1) the function of the barricade, 2) the consequences of failure to safe use of the facility and 3) the degree of disruption caused while repairs are being carried out if failure occurs[6]. However, the factor of safety should be ≥1.2 in the long term.

In the case of a reinforced fill slope, information from the manufacturer shall be required to determine the number and type of reinforcements, embedded lengths and vertical spacing.[7] The early involvement of the manufacturers of these materials in the design process is essential. Where a vertical, or near vertical i.e. >70° face using a wrap-around detail or pre-cast concrete facing element is envisaged for the reinforced fill, the fill material shall be free-draining and shall comply with the requirements of the manufacturer of the reinforcement. Since such a configuration constitutes a 'wall', the factor of safety against sliding should not be less than 2.0 and that against rotational slip not less than 1.5.

[5] See IATG 05.20 *Types of buildings for explosive storage*.

[6] See IATG 02.10 *Introduction to risk management principles and processes.*

[7] See IATG 05.20 *Types of building for explosives storage.*

Measures should be taken to prevent the burrowing of rabbits, termites or other burrowing animals into a barricade. Advice and typical details of protection from burrowing animals may be obtained from specialist agencies.[8] This is important because if a barricade subsides, even by a small amount, it will reduce the amount of explosive that may be legally held at the PES.

If a barricade is unlikely to be dispersed by an explosion, then it need not be constructed of special materials. However, this severely limits storage flexibility and it would be better to construct the barricade of the material specifications listed in Table 1. Earth cover for earth covered buildings ECMs are also required to meet the requirements of the materials listed in Table 1.

Material Description *(In preference order)*	**Grading Limits (1) (2)**				**Design Slope (4)** *(Dependant on soil mechanics)*
	Coarse Material		**Fine Material**		
	Maximum Particle Size	**Maximum Content (% by Weight: 20 – 75mm)**	**Maximum Fines Content (% by Weight: <63µm)**	**Maximum Clay Content (% by Weight: <2µm)**	
Well Graded Sand	6.3mm	0%	15% (1)	5% (1)	1:1.5 to 2 (33^0 to 26^0)
Well Graded Gravelly or Clayey or Silty Sand (inorganic)	7.5mm	5% (1)	20% (1)	5% (1)	1:1.3 to 2.5 (37^0 to 21^0)
Inorganic Fill (3)	Other inorganic material meeting the above grading requirements				

Table 1: Construction materials for barricades

NOTE 1 Coarse and fine particles shall be uniformly distributed throughout the material to provide a homogenous fill.

NOTE 2 The material used should have a Uniformity Coefficient (D_{60} / D_{10}) of 6 or greater.

NOTE 3 Rubble from demolished buildings or any other similar material shall not be used in the construction of barricades due to the risk of enhanced projection hazard.

NOTE 4 Slope stability requirements are defined in this IATG module; design slopes tabulated are indicative only and will vary dependent upon:

a. The nature and strength of foundation soil and rock and depth to the water table;
b. The degree of compaction and surface preparation provided to the fill;
c. The fines content and erosion potential of the fill materials;
d. The compaction moisture content where the fill materials are not free draining;
e. The provision of drainage measures to control short/long-term pore water pressures; and
f. The fill being reinforced with geo-synthetics, wire mesh etc.

8 Earth barricades (LEVEL 1)

It is essential that barricades have the correct geometry. It mitigates against the risk of high velocity fragments or debris escaping above or around the ends of the barricade. Generous margins in barricade dimensions should be provided so that lines of sight are totally blocked.

8.1 Barricade height

To eliminate height line of sight problems, the dimensions for an earth barricade should be controlled by the 2-degree rule. This is illustrated at Annex C. This rule does not apply to separation distances less than PES $<5Q^{1/3}$. Where PES are separated by a distance of $>5Q,^{1/3}$ barricades should be assessed individually. An alternative to the 2-degree rule is to ensure that there is at least 0.6m of additional barricade height along the line of sight from one PES to another.

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[8] Some experience suggests that the use of appropriate insecticides mixed in with the earth during barricade construction has a good effect.

A barricade may be constructed with a minimum width of 2.4m at a level equal to the maximum height of the stored explosives, plus an extra 600mm. A barricade may also be erected to the height of the eaves of the building, which the barricade protects. These requirements are illustrated at Annex D.

Should low stacks of explosives be stored in a PES and the 2-degree rule leads to barricades being lower than the eaves of the building, consideration shall be given to increasing the barricade height up to the building eaves. This will assist in limiting building debris throw. However, this may lead to unusually high barricades.

8.2 Barricade length

Ideally, a barricade should surround the PES it protects as this allows flexibility in further development. However, should this not be the case then it should extend, without any reduction in overall height, beyond the sides of the PES to eliminate any potential lines of sight to other PES and ES. This length shall be not less than 1 metre at each end of the barricade on all barricaded sides of the PES. Annex C provides a diagrammatic of this situation.

8.3 Slopes

Barricade shall be sloped such that they are stable. This slope will vary with the construction materials used but should normally be no steeper than 1:2 or 26° from the horizontal. The flatter the slope, the less erosion and hence less maintenance required.

9 Other materials compared to earth (LEVEL 1)

Should brick, concrete or steel be used to support the vertical face of a type 2 or a type 3 barricade (see Clause 10), their effectiveness in stopping high velocity fragments is increased when compared with a pure earth barricade. These effectiveness figures are at Table 2.

Material	Effectiveness compared to soil (nominal value of 1)
Brick	x 4
Concrete	x 6
Steel	x 24

Table 2: Effectiveness of materials compared to soil

This effectiveness means that barricade thickness may be reduced accordingly. However, the equivalent mass of an interceptor barricade should not be reduced below 2.4 m of earth at the top level of the stack or eaves of the PES to prevent dispersion of the barricade occurring.

9.1 Wall barricades (LEVEL 2)

Concrete or masonry walls of buildings may be used as barricades. However, they must be designed with this role in mind. Existing walls will probably not be suitable for the task. Where explosives or personnel are to be protected, the walls should be designed to resist collapse. For small NEQs such as those to be found in process buildings, Table 3 lists the thickness required for cantilever container barricades of 3m maximum height at 1m stand off from the explosives in order to prevent collapse. For larger NEQs, specialist advice should be obtained.

NEQ (kg)	RC Wall Thickness Buttressed at 3 m Centres, with 0.2% Tension Reinforcement. (mm)	Nominal Brick Wall Thickness (mm)
2.5	225	340
5	225	340
7	225	450
12	225	570
18	300	680
35	450	Not permitted
50	600	Not permitted
68	750	Not permitted

Table 3: Thickness required for cantilever container barricades.

9.2 Other barricade types (LEVEL 1)

There may be occasions, such as field storage of ammunition, when the use of improvised barricades will be required.

Full scale testing is often the basis for validating the effectiveness of use of other non-traditional barricade designs. New tests should be conducted for situations where the limitations or conditions associated with the initial approval for use of the barricade involved are exceeded or the impacts unknown.

9.2.1. Use of HD 1.4 ammunition as a barricade

Ammunition of HD 1.4 may be stacked so as to provide buffered storage protection between stacks of other HD. However, these stocks of HD 1.4 may be destroyed in the event of the explosion of an adjacent stack. This use of HD 1.4 should only be considered in an emergency.

9.2.2. Water barriers

Several propriety water barriers are available . They are effective but should only ever be considered as temporary due to long term survivability and maintenance issues. Water is an effective medium for slowing down high velocity fragments. Maintenance of the water tanks in extremes of temperature is also problematic.

9.2.3. Soil barriers

Several propriety soil-filled barriers are also available. The filling of these should meet the requirements of the materials listed in Table 1.

9.2.4. Unitization[9] (LEVEL 2)

Unitization is the partitioning of explosives in individual compartments using dividing walls or by using internal barricades. In some cases, this allows reduced QDs to be used. The subject of unitization is a complex one and specialist ammunition technical advice should be obtained before its application and subsequent reduction in QDs is authorised.[10] This concept is generally only applicable to small NEQ < 200 kg.

10 Design of barricades and their variable functions (LEVEL 2)

There are six constructional designs of barricades:

a) Type I. This is a double slope earth mound construction;

b) Type II. A single slope vertical face earth mound, or partial vertical face mound;

c) Type III. A steep double slope earth mound sometimes referred to as a 'Chilver' type;

d) Type IV. Often described as a bunker building or combined barricade. This type includes fully buried buildings not more than 600 mm below ground level; [11]

e) Type V. These are wall barricades constructed of brick, reinforced concrete and composite construction; and

f) Type VI. Natural features of a site such as mounds, hillocks and so forth. As a minimum, they are to be the same size as a type I.

It would be unwise to tightly define the use of each type of barricade because the functions and protective features often overlap. However, in general, Types I, II and III, comprising sloping barricades, are the most used for storage purposes. They are the most functional because they can function in all four protective roles (see paragraph 5). Type IV barricades make use of the PES structure to support the earth and Type V barricades are primarily used as receptor barricades or are designed as container barricades. Diagrams of these barricades are at Annex C.

11 Barricade protection against blast overpressure

General procedures to predict pressure mitigation versus general barricade design types and their location have to date not been developed. Yet based on direct-experimental work, the overpressure loading on a surface area shielded by a barricade is reduced by approximately 50 percent when the following conditions are met:

a) location. The barricade's stand-off is within two barricade heights of the protected area;

b) height. The top of the barricade is at least as high as the top of the protected area; and

c) length. The length of the barricade is at least two times the length of the protected area.

[9] See IATG 02.20 *Quantity and separation distances.*

[10] As an example, one national requirement for the use of internal barricades is that they should be constructed using autoclaved aerated concrete blocks or an approved equivalent as barriers. The barrier thickness shall be a minimum of 300 mm. Autoclaved aerated concrete blocks are designed to be sacrificial and shall have a density of 550 - 750 kg/m^3 and a compressive strength of 4 - 5 N/mm^2. The blocks need not be mortared together thus enabling cells to be readily adjustable in size to suit storage requirements.

[11] If deeper than 0.6m the building may have to be considered as underground storage.

Annex A
(normative)
References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this module . For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this module 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 abbreviations*. UNODA;

b) IATG 01.50 *UN Explosive hazard classification system and codes*. UNODA;

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

d) IATG 02.20 *Quantity and separation distances.* UNODA; and

e) IATG 05.20 *Types of buildings for explosive storage.* UNODA.

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UNODA) holds copies of all references[12] 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 management programmes.

[12] 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:[13]

a) AASTP-1, Edition B, Version 1. *NATO Guidelines for the Storage of Military Ammunition and Explosives.* NATO Standardization Organization (NSO). December 2015. http://nso.nato.int/nso/nsdd/listpromulg.html;

b) *Handbook of Best Practices on Conventional Ammunition*, Chapter 2. Decision 6/08. OSCE. 2008;

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

d) Technical Paper 15, Revision 3, *Approved Protective Constructions*. US Department of Defense Explosive Safety Board (DDESB). May 2010. www.wbdg.org/building-types/ammunition-explosive-magazines; and

e) UFC-3-340-02, *Structures to Resist the Effects of Accidental Explosions*. US Department of Defense. 05 December 2008; Change 2, 01 September 2014. www.wbdg.org/building-types/ammunition-explosive-magazines

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UNODA) holds copies of all references[14] 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 management programmes.

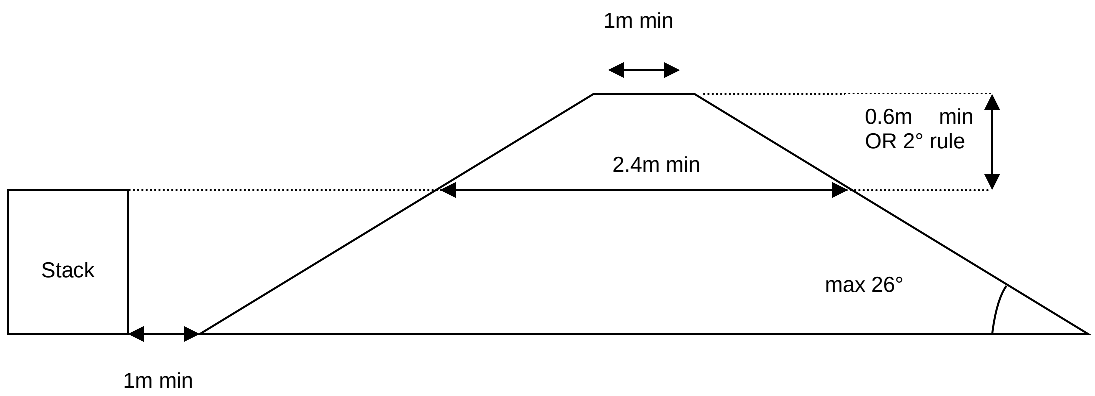
[13] Data from many of these publications has been used to develop this IATG.

[14] Where copyright permits.

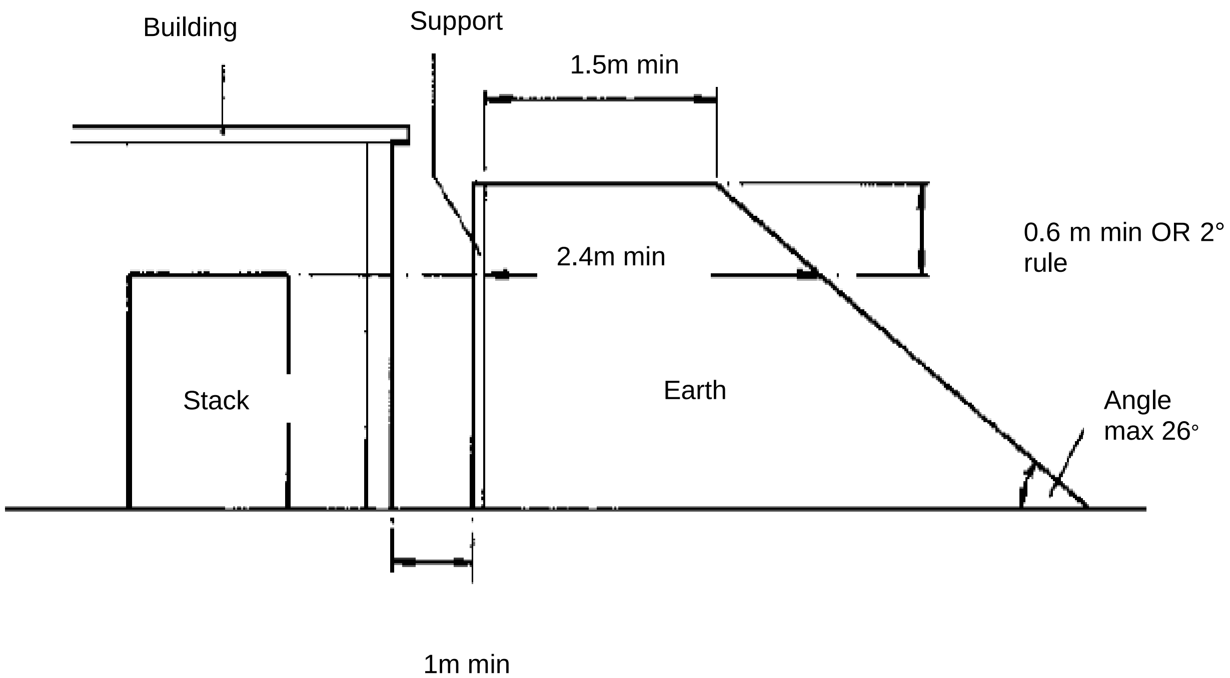
Annex C
(informative)
Types of barricades

This annex provides a definitive list of barricade types. It is intended to identify the various types of barricades and their design. All diagrams that follow in this IATG are courtesy of the UK Joint Service Publication 482, Volume 1, Chapter 7, *Barricades*.

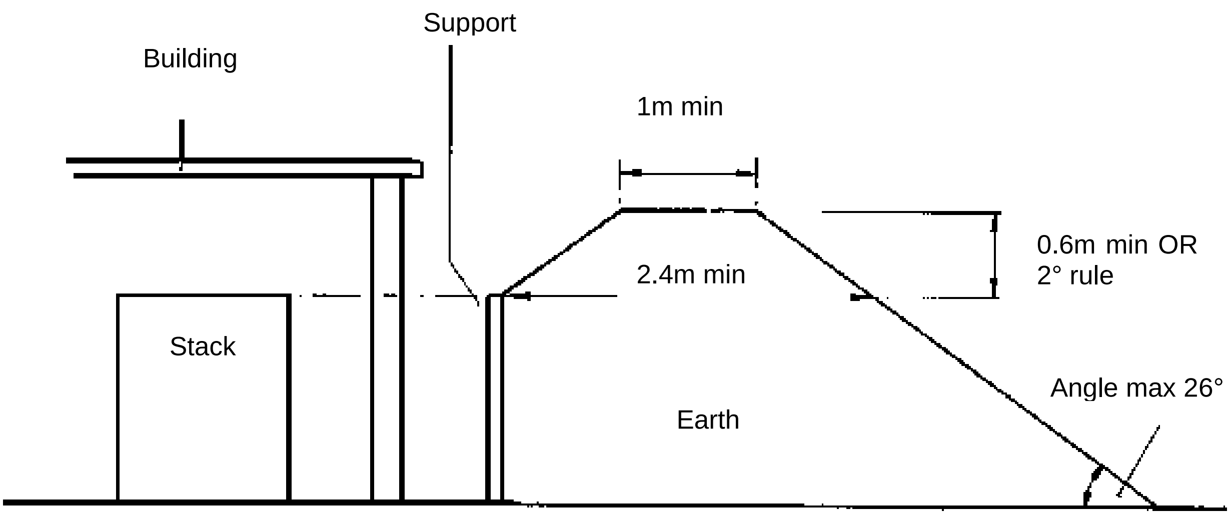
C.1 Type I – standard double slope



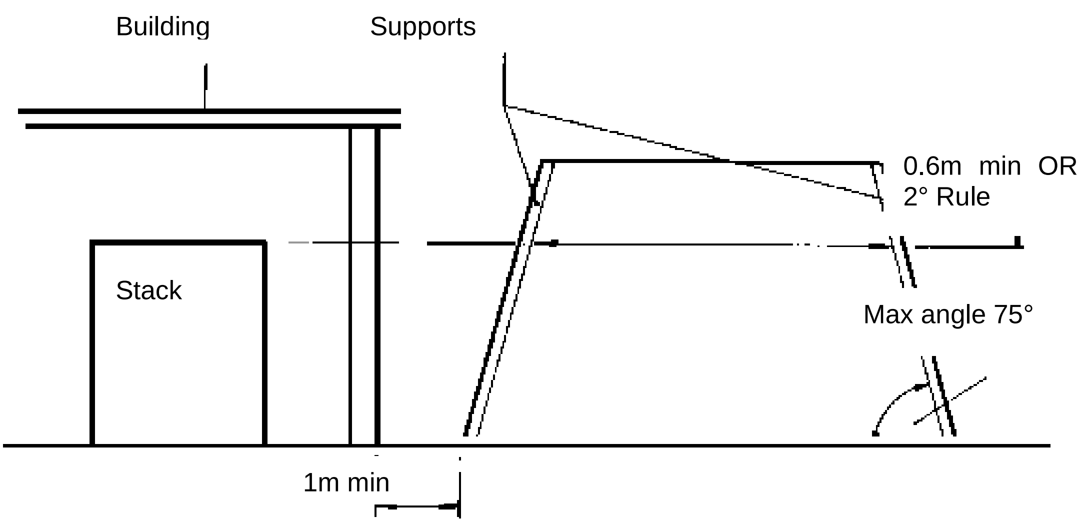
C.2 Type II – single slope vertical face type



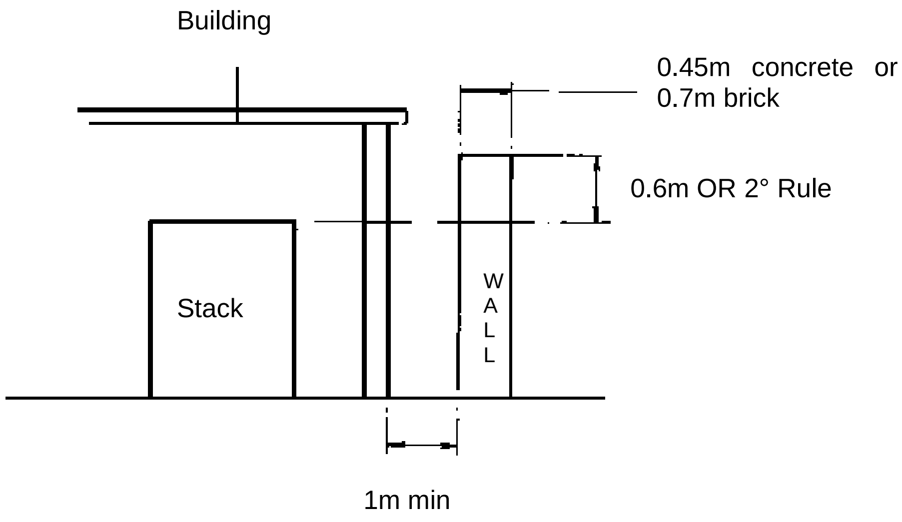
C.3 Type II – partly vertical partly sloped face type



C.4 Type III – steep double slope (Chilver) barricade



C.5. Type V – wall barricade



Annex D
(informative)
Height of barricades – determination

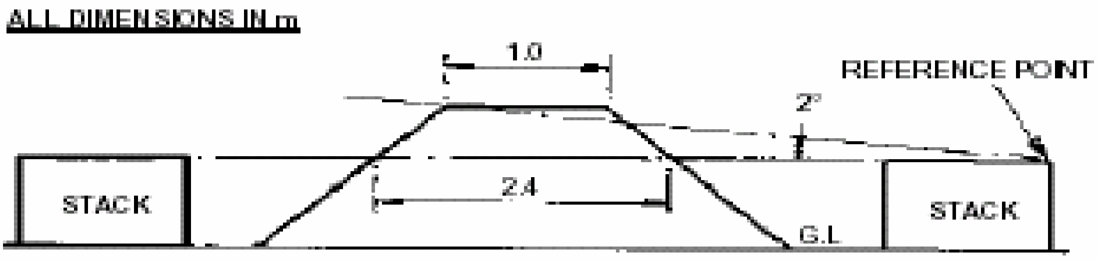


Fig 1 Determination of Traverse Height on Level Terrain

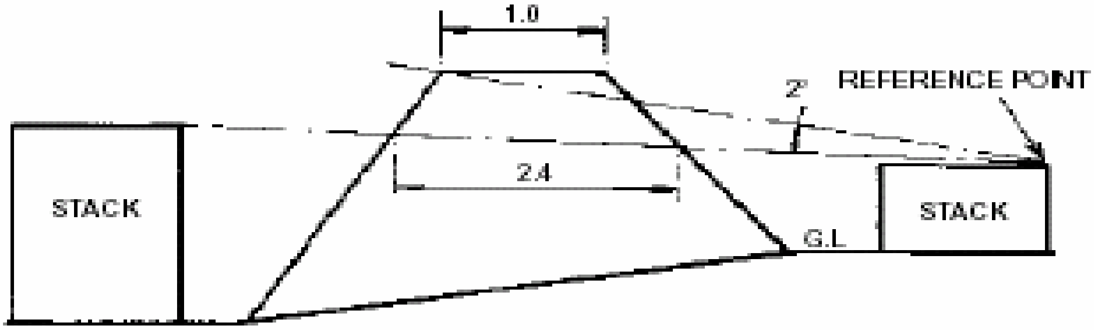


Fig 2 Determination of Traverse Height on Sloping Terrain

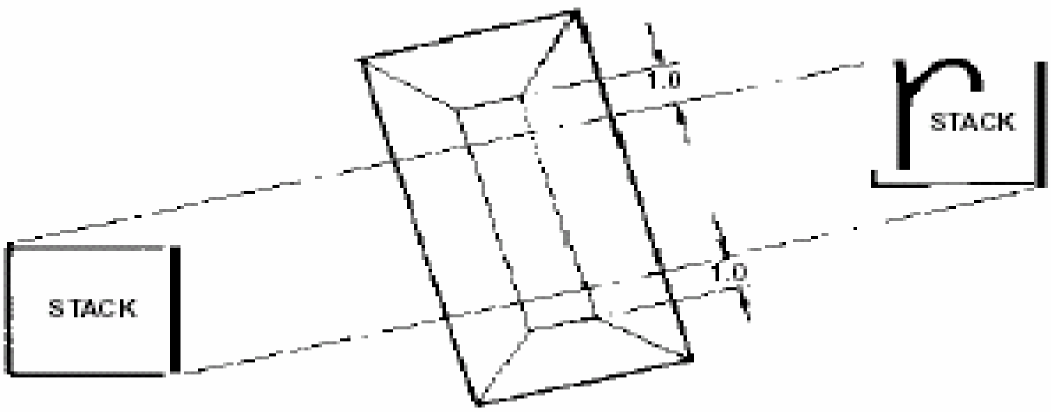


Fig 3 Determination of Traverse Length

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.