# NATO STANDARD

# ATP-3.12.1.8

# TEST PROCEDURES AND CLASSIFICATION OF THE EFFECTS OF WEAPONS ON STRUCTURES

**Edition A, Version 1**

**JUNE 2016**

**NORTH ATLANTIC TREATY ORGANIZATION**

**ALLIED TACTICAL PUBLICATION**

**Published by the**
**NATO STANDARDIZATION OFFICE (NSO)**

INTENTIONALLY BLANK

# NORTH ATLANTIC TREATY ORGANIZATION (NATO)

# NATO STANDARDIZATION OFFICE (NSO)

# NATO LETTER OF PROMULGATION

10 June 2016

1. The enclosed Allied Tactical Publication ATP-3.12.1.8, Edition A, Version 1, TEST PROCEDURES AND CLASSIFICATION OF THE EFFECTS OF WEAPONS ON STRUCTURES, which has been approved by the nations in the MCLSB, is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 2280.

2. ATP-3.12.1.8, Edition A, Version 1, is effective upon receipt.

3. No part of this publication may be reproduced, stored in a retrieval system, used commercially, adapted, or transmitted in any form or by any means, electronic, mechanical, photo-copying, recording or otherwise, without the prior permission of the publisher. With the exception of commercial sales, this does not apply to member or partner nations, or NATO commands and bodies.

4. This publication shall be handled in accordance with C-M(2002)60.

Edvardas MAŽEIKIS
Major General, LTUAF
Director, NATO Standardization Office

INTENTIONALLY BLANK

**RESERVED FOR NATIONAL LETTER OF PROMULGATION**

INTENTIONALLY BLANK

# RECORD OF RESERVATIONS

| CHAPTER | RECORD OF RESERVATION BY NATIONS |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

INTENTIONALLY BLANK

# RECORD OF SPECIFIC RESERVATIONS

| [nation] | [detail of reservation] |
|---|---|
| DEU | Reservation 1:<br>- Germany reserve the right to perform the following changes: Annex B Page B 3-5 Nr. 13b<br>Delete: « … personnel with access to the CONventional WEPons modelling tool CONWEP. As such, … »<br>Delete: Footnote 1<br>Insert: « … personnel with access to suitable software tools. As such, … »<br>Rational:<br>The addressed tool CONWEP is not available for everybody, since it contains restricted information. Therefore it cannot be assumed, that every governmental or non-governmental organization has access to CONWEP. Nevertheless the STANAG indicates that solely CONWEP calculations are permitted for qualification. In the meantime there already exist (or are being developed at the moment) alternative tools which are using the same (or even better) algorithms. These tools must not be excluded from being used in the sense of this ATP. An alternative way of not listening CONWEP would be to list these alternative tools.<br><br>Reservation 2:<br>- Germany reserve the right to perform the following changes: Annex B Page B 3-6 Nr. 16<br>Delete: « … use the CONWEP to calculate … »<br>Insert: « … use suitable tools to calculate … »<br>Rational: See rationale No 1.<br><br>Reservation 3:<br>- Germany reserve the right to perform the following changes: Annex B Page B 3-1 Nr. 3<br>Insert:<br>3. (…) is acceptable.<br>4. Alternatively, the required blast load can be simulated by using a shock tube according to STANAG 4524 - AEP-25, chapter 3.<br>Preparation of Trial<br>5. Protective …<br>Rational:<br>An approved alternative to free field tests are shock tube tests, especially for NEM of more than 1000 kg. Therefore this alternative |

| | |
|---|---|
| | method to generate shock waves should definitely be mentioned in the ATP.<br>The shock tubes of the WTD 52 offer the possibility to test multistory structures against blasts, which meet the blast effect of tons of explosive closely. |
| DNK | Denmark will probably not use leves above 5 for deployed structures.<br>It is proposed that there is to be a study of limits for low pressure damage to the brain ("Black Areas"). |
| FRA | France will refer to the European normative document "CEN Workshop Agreement 16221", which has a larger audience than the British normative document BS PAS 68 (reference G, ATP 3.12.1.8). |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations. | |

# TABLE OF CONTENTS

INTENTIONALLY BLANK

# CHAPTER 1 - INTRODUCTION

## Intended Readership

0101. This publication is principally intended for use by technically qualified engineers (eg, EUR ING) though the main document (pages 1 - 4) and Annex C are intended to be read and used by all military engineers. It is not intended/expected that other arms will read/use the ATP but military engineers should use appropriate parts to brief other commanders (eg, Annex C - Assessment of the Protective Levels of Structures).

## Aim

0102. The aim of this ATP is to provide a common understanding of the protection offered by structures, whether purpose-built 'military specials' or existing buildings, against projectiles, fragments, blast effects and vehicle penetration. This standard should enable:

a. Military engineers and other arms to communicate information about the protection provided by structures against the effects of different weapons, clearly and accurately, both within and between nations.

b. A clear understanding of the protection provided by structures, such that this can be considered against national requirements, thus allowing multi-national occupancy of infrastructure built by other nations on operations.

c. The effective transfer of infrastructure ownership during relief in place or handover operations.

d. A common understanding of weapons effects (Annex A) and standards for testing infrastructure (Annex B) to be established, allowing the continued use of national testing and evaluation protocols whilst making it possible for the results/protective levels, designs etc to be shared with and understood by other nations/industry.

e. A common understanding of threat assessments/weapons effects when setting user requirements for operational infrastructure.

f. The provision of information and guidance to technically qualified military engineers on operations, to assist with assessing existing and designing new protective structures.

g. Engineering structural risk assessments to be conducted by using information about the protective levels of structures collected on the form at Annex C, (Assessment of the Protective Levels of Structures).

0103. This ATP is only intended to provide guidance for the assessment and design of expeditionary field structures. It is not to be used as an authoritative engineering reference for designing or assessing permanent defensive structures such as Hardened Aircraft Shelters.

**Scope**

0104. This ATP covers:

a. Common military projectiles, fragmentation, vehicle and blast weapons, as well as a generalized spectrum of blast threats, which includes the characteristics of the majority of Improvised Explosive Device (IED) attacks.

b. The effects of weapon systems on infrastructure, including the following:

(1) Blast;

(2) Penetration:

i. Bullets and penetrators;

ii. Shaped Charges;

iii. Vehicles;

(3) Fragmentation;

(4) Secondary Effects (including spalling and fire);

0105. This ATP does not cover some weapons effects, including:

a. Flame and Thermal Pulse;

b. Chemical Biological Radiological and Nuclear (CBRN);

c. Electromagnetic and Radiation Effects;

d. Air-delivered munitions;

e. Environmental threats (eg, flooding).

# CHAPTER 2 - BACKGROUND

## Force Protection

0201. This document will assist military engineers to provide the vulnerability assessments element of wider Force Protection considerations, as depicted below in Figure 1: Force Protection Model in Reference H (Edn 2, SD3, dated 20 Dec 12). The diagram illustrates how the threat assessment must be completed early in the process, leading to the infrastructure vulnerability assessment which contributes to a much larger process considering the overall protection requirements.

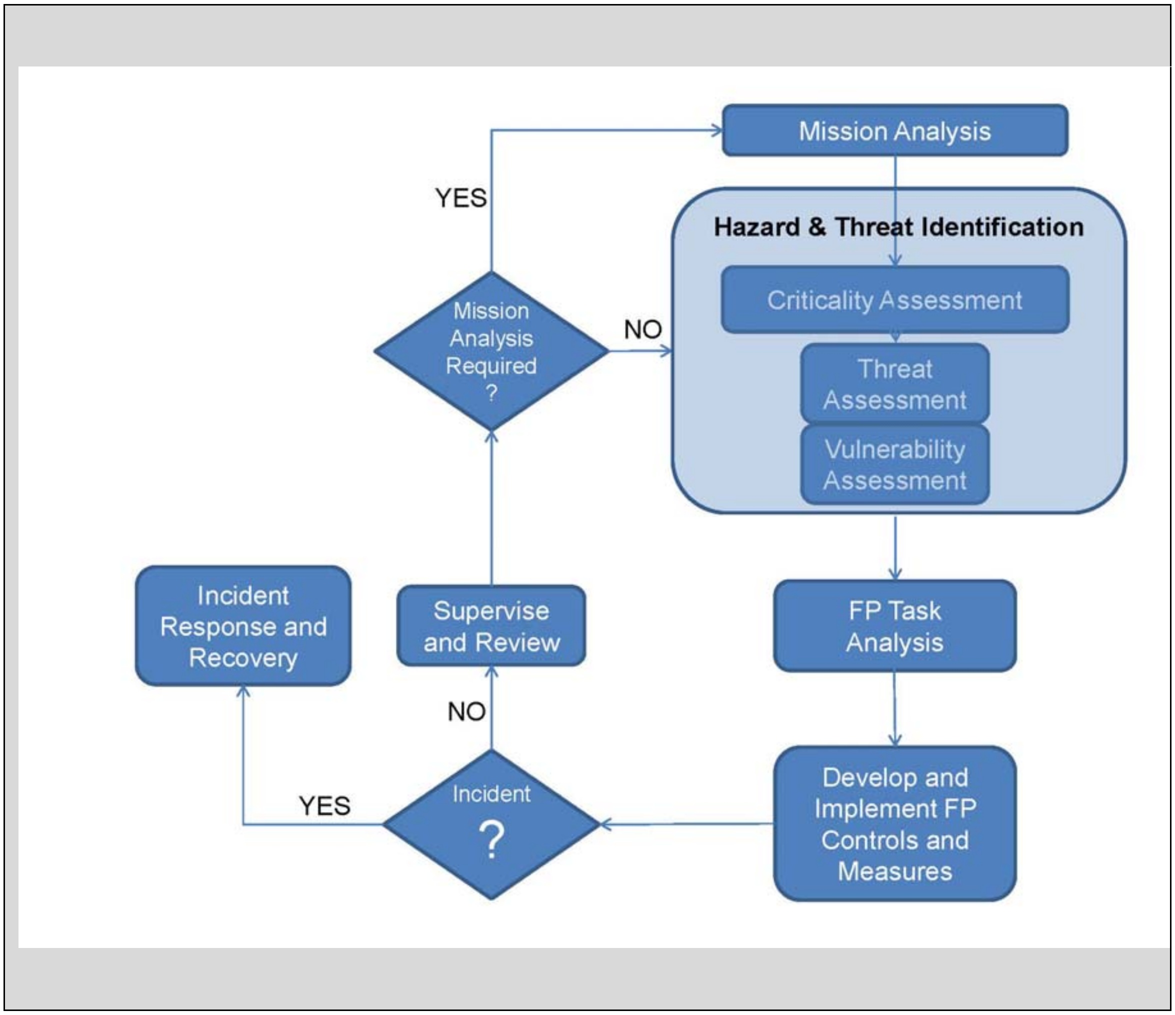



**Figure 1**: Force Protection Model

0202. In order to ensure a common standard of protection, representative weapons have been grouped by category and severity of effect (not necessarily in order) in Annex A. Using this information should ensure that, despite the different construction methods and materials used by nations, there will be a common approach to testing (Annex B) and understanding of the protection provided by structures.

0203. Nations will normally use standard designs when building operational infrastructure, based on output from national research and development (R&D) organizations and the skills developed in national training establishments. Additionally, ACO Directive (AD) 80-25 (ACO Force Protection - NR) provides direction and guidance about Force Protection for operational level planners, as well as giving practical examples for tactical level units[1]. It links each NATO weapon category to the level of protection to be provided by the infrastructure and gives design specifications for the protective measures that may be used. Annex C, the Assessment of the Protective Levels of Structures, provides a simplified summary of the critical information related to the assessment of the protective levels of structures. It should be completed as the infrastructure is built or, in the case of existing structures, as they are occupied, with a copy being held in the camp/base asset registry and passed on as part of any subsequent handover.

0204. For expediency, shortage of materiel, equipment or expertise, operational infrastructure may be based on or incorporate existing structures (~hybrid) or incorporate improvised components. In such cases, the user should estimate (based on experience/data about similar structures) or calculate (taking structural measurements, where possible) the protection levels provided by the structure; on occasions there may be a requirement to conduct tests to assist with this assessment (although destructive testing of existing structures is unlikely to be possible). The form at Annex C has been designed to assist with the assessment of existing or hybrid structures.

## Assessment of the protective levels of structures

0205. The form at Annex C enables test results/assessments to be recorded and communicated within and between nations in a clear format, with a common understanding of pass/fail criteria. This will allow nations to assess the protection provided by their own or another nation's infrastructure and enable risk assessments to be conducted.

0206. The form should be a living document, completed by military engineers, updated as changes are made to structures and held with the asset registers for a base or facility. The form is a concise way of summarizing and describing protection levels, to assist with the conduct of relief-in-place or handover operations. It is not a risk assessment in itself but it contributes to the completion of a risk assessment.

0207. **New structures**. The process for establishing the protective levels required of new designs is as follows:

b. Identify the threat weapon categories;

c. Establish the required levels of protection;

d. Design the structure and establish the likely failure modes;

[1] AD 80-25 refers to STANAG 2280 Edition 2, with 5 levels of weapon effects rather than the 9 of Edition 3. It will be reviewed accordingly.

e. Establish the required levels of assurance, conduct trials and analyse results;

f. Identify additional mitigation measures if necessary; repeat c, d, e as required;

0208. **Existing or hybrid structures**.

a. Identify the threat weapon categories;

b. Analyse the structure;

c. Establish the required levels of assurance, conduct trials and analyse results;

d. Identify additional mitigation measures if necessary; repeat b, c, d as required.

0209. **Infrastructure register**. Table A – 1 (Weapon Categories and Severity of Effect) and the completed Annex C (Assessment of the Protective Levels of Structures) should be held by base/installations as part of the infrastructure register.

INTENTIONALLY BLANK

# CHAPTER 3 – AGREEMENT

0301. Participating nations agree to adopt the tables of weapon categories and severity of effect in Annex A and to use the appropriate designation when describing the design threat to other nations.

0302. Participating nations agree to adopt the guidelines for testing as described in Annex B as far as reasonably practicable, whenever tests are used in a qualification process.

0303. Participating nations agree to use the form at Annex C (Assessment of the Protective Levels of Structures) during handover of protective structures to other nations in order to describe the protection level as well as validation method employed.

0304. This document is unclassified. However, Annex C may be given a national security caveat once completed with information relating to a specific structure/location.

INTENTIONALLY BLANK

# ANNEX A - WEAPONS CATEGORIES AND SEVERITY OF EFFECTS

## A.1 Weapon Hazards

The hazards caused by various weapons have been defined in order to assist with classifying the weapons; the extract below has been taken from Reference B.

***CHAPTER 4 WEAPON EFFECTS***

***SECTION 4.1 WEAPON HAZARDS***

*0401. The chapter outlines the more common physical weapon effects that a deployed, expeditionary force is likely to encounter; more detailed explanation is given in Military Engineering Volume IX, Part 2 Security Systems and Existing Structures. Depending on the specific characteristics of a particular weapon, it is likely to have one or more means of causing injury and damage.*

*0402.* ***Blast.*** *When an explosive detonates it produces a pressure shock wave that moves exceptionally quickly. If placed in contact with a material, extremely high stresses are transmitted from the explosive causing it to shatter. If the explosive is surrounded by air, a blast wave is produced. Normally this pressure bubble dissipates over distance; however, confining the explosion enhances its effect. If the explosive is surrounded by earth, the shock wave propagates in a different manner and induces ground shock and may produce a crater.*

*0403.* ***Penetration.*** *Weapon fragments and other projectiles are able to penetrate protective materials and cause injury.*

*a.* ***Bullets and Penetrators.*** *Bullets and other projectiles are designed to be aerodynamically stable in flight. Generally, they travel further and penetrate deeper into a target than fragments from a weapon casing.*

*b.* ***Shaped Charges.*** *Explosive charges can be pre-shaped to focus their blast effect on to a part of their container. On detonation, this section of the container is driven outwards and acts like a projectile; its extreme high speed causes it to penetrate a great depth into any material.*

*0404.* ***Fragmentation.*** *As a weapon explodes, material around it is broken up and thrown outwards as fragmentation. Primary fragments are those that are formed from the weapon casing itself. They are generally very small and highly energetic, often initially travelling at several times the speed of sound. Secondary fragments are those items of debris picked up by the blast wave and thrown outwards. They are generally much slower but often far heavier.*

*0405.* ***Flame and Thermal Pulse.*** *All explosions are accompanied by a fireball and thermal pulse. For most conventional weapons, the damage these cause is much less significant compared to that caused by blast and fragmentation. However, some weapons are optimised to injure using flame or thermal pulse.*

*0406.* ***Chemical and Biological Effects****. Chemical and biological weapon agents are usually transmitted through the air or, occasionally, through water. They therefore present either a vapour or contact hazard. They are not covered in any depth in this publication.*

*0407.* ***Electromagnetic and Radiation Effects****. Nuclear weapons pose both a radiological and nuclear hazard. Other weapons may also exploit the electromagnetic spectrum. They are not covered in any depth in this publication.*

Note that hazards 0405 (flame/thermal pulse), 0406 (chemical and biological) and 0407 (electromagnetic and radiation) are not covered in this STANAG.

### A.2 Weapon categories and severity of effect

Common weapons systems have been categorised and assigned a severity of effect, as shown in the table below.

| | | **Weapon Category** | | | | |
|---|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** | **E** |
| | | **Projectiles[1]** | **Direct Fire Warheads[3]** | **Indirect Fire Munitions[3,4]** | **High Explosives (TNT Eqvt)** | **Moving Vehicles[5]** |
| **Severity of Effect (level)[7]** | **9** | | | | ≤ 5,000kg | |
| | **8** | **120/125mm** SABOT<br>**Anti tank** | **Anti-tank** 120/125mm<br>HESH / HEAT | Scud | ≤ 1,000kg | |
| | **7** | **Automatic cannon**<br>40mm APDS | | 333mm Rocket | ≤ 250kg | |
| | **6** | **Automatic cannon**<br>30mm APDS | **Advanced ASM**<br>Anti Structure Munitions | 240mm Rocket | ≤ 50kg | Tracked Vehicle |
| | **5** | **HMG**<br>14.5mm (0.57) | **Tandem ASM** | 155mm Artillery<br>122mm Rocket | ≤ 10kg | Large Truck<br>≤ 32,000kg |
| | **4** | **HMG**<br>12.7mm (0.50) | **Anti-personnel**<br>Thermobaric or conventional charge <2.5kg | 120mm Mortar<br>107mm Rocket | ≤ 2kg | Truck<br>≤ 7,500kg |
| | **3** | **Assault /Sniper Rifle**<br>7.62mm AP | **Anti-tank**<br>Shaped charge | 82mm Mortar | ≤ 1kg | Small Truck<br>≤ 2,500kg |
| | **2** | **Assault Rifle**<br>5.56 - 7.62mm Ball | **40mm Rifle grenade**<br>shaped charge | 60mm Mortar | ≤ 0.5kg | Passenger Car<br>≤ 1,500kg |
| | **1** | **Pistol** | (reserved) | Hand grenade | ≤ 0.1kg | Motorcycle |
| Weapon Hazards | | Dynamic penetration | Dynamic penetration<br>Fragmentation<br>Shaped Charge<br>Blast[6] | Dynamic penetration<br>Fragmentation<br>Blast | Blast<br>Fragments (VBIED) | Dynamic penetration |
| Failure Modes | | Perforation | [2]Perforation (inert components)<br>Perforation (fragments)<br>Perforation (shaped charge)<br>Blast | [2]Perforation (inert components)<br>Perforation (fragments)<br>Blast | [2]Blast | Perforation (inert) |

**Table A-1:** Weapon Categories and Severity of Effect

Notes.

1. IAW testing protocols found in the appendices, all trials will be single shot applications except for Weapon Category A which will be a series of three rounds.
2. If pre-detonation screens are part of the structure, testing is to occur with the screens in place.
3. If the threat assessment includes delay-fused munitions, static trials should be set up such that the warhead detonates at a location in accordance with the additional distance travelled from initial point of impact (on structure or pre-detonation screen).
4. There is no dedicated category for overhead protection. The envelope of protection is considered as a whole.
5. The vehicle and explosive have been decoupled for VBIED scenarios. Category E is a non-explosive assessment of barriers.
6. Blast includes structural and personnel vulnerability. Structural failure includes heaving, breaching, and other deformation modes; personnel failure ranges from eardrum damage to lethality.

7. Threats greater than Severity 9 exist. If data is available on such threats or different hazards (eg incendiary), comments can be added to the form at Annex C. It is not intended to suggest that comparisons can be made between, for example, different categories of weapon at the same level of severity.

The purpose/method of testing the various categories of weapons are described in the Appendices. The detailed methods for conducting weapon trials are at Annex B.

List of appendices:

1. Weapon Category A - Small / Medium Calibre Projectiles;
2. Weapon Category B - Direct Fire Warheads;
3. Weapon Category C - Indirect Fire Munitions;
4. Weapon Category D - High Explosives;
5. Weapon Category E - Moving Vehicles.

## WEAPON CATEGORY A - SMALL / MEDIUM CALIBRE PROJECTILES

### Aim

1. The aim of the test should be to emulate the effect of short bursts of automatic fire.

### Failure Mode

2. Penetration is the only failure mode for this category of weapon. If a round perforates (passes completely through the target), the target is over-matched and considered to have failed for that particular level.

### Representative Weapons

3. The weapons listed in the table below are representative examples and their properties should be used for testing and classification of structures when possible. Deviations, changes or omissions may be necessary but must be documented. Due to the large number of types and manufacturers, actual data may vary from those listed in the table. Technical data are manufacturers' figures except when stated otherwise.

4. This is not in a strict order of severity. Depending on the variables, such as type of target and distance, some of the weapons in the same group may perform noticeably differently and a weapon in A1 might have a more severe effect than one in A2. Therefore it is important to state which weapons have been used in the tests to enable more accurate analysis to be completed and judgement to be exercised when a particular threat is apparent.

| | | **Weapon system example** |
|---|---|---|
| A9 | | |
| A8 | **120/125mm**<br>APDS/APFSDS | |
| A7 | **Automatic cannon**<br>40mm APDS | |
| A6 | **Automatic cannon**<br>30mm APDS | 30mm APDS<br>25mm Bushmaster |
| A5 | **HMG**<br>14.5mm (0.57) | 14.5mm AP |
| A4 | **HMG**<br>12.7mm (0.50) | 12.7mm AP / API / MPT |
| A3 | **Assault /Sniper Rifle**<br>7.62mm AP | 7.62mm AP |
| A2 | **Assault Rifle**<br>5.56 - 7.62mm Ball | 7.62mm x 39mm Ball<br>7.62mm x 51mm Ball<br>5.56mm Ball |
| A1 | **Pistol** | 9mm pistol<br>PP-90 SMG |

**Table A 1-1:** Representative weapons.

## WEAPON CATEGORY B – DIRECT FIRE WARHEADS

### Aim

1. The aim of the test should be to emulate the effect of the detonation of a single warhead, either static or fired directly at the protective structure (dynamic test).

### Failure Modes

2. The failure modes for Weapon Category B is:

   a. Fragment penetration;

   b. Shape charge penetration;

   c. Blast damage;

   d. Dynamic penetration.

3. A dynamic test should be conducted to determine the dynamic penetration of non-functioning projectiles and components such as rocket motors.

4. The weakest representative section of the protective structure should be tested and pre-detonation screens should be tested if they are part of the structure; if there are no pre-detonation screens, the warhead is to be detonated in contact with the target. If delayed fuses can be used with the weapon it should be detonated in the position that best represents the point at which it is assessed that the weapon would detonate. A witness panel should be placed behind the target to confirm penetration.

5. Detonation screens must be tested to ensure that they achieve the desired effect when struck by a weapon, for example by stopping the weapon from functioning (fail safe) or causing it to function in such a way that its effect against the structure being protected is greatly reduced. Multiple tests should be conducted to take account of the variety of detonation screens available and the different ways in which a warhead may interact with a screen. Tests should be conducted at different impact angles and against different parts of the structure, for example:

   a. Perpendicular to the screen

   b. At $45^0$ to the screen, both horizontally and vertically if the material is not homogeneous and has different properties in different directions (eg reinforcing bars in concrete only aligned vertically).

   c. Different parts of a repeated panel or mesh screen, where the centre of each section may behave differently to the outer edge which may be supported by a frame.

6. The effects achieved by the detonation screen are described with reference to the whole weapon and not the subsequent hazards, such as pieces of weapon or an explosive jet striking the structure being protected. In each of the descriptions below, the screen will have achieved the intended effect and greatly reduced the effect of the weapon on the structure being protected by the screen:

   a. Fully functioning detonation

   b. Partially functioning detonation

c. No detonation but penetration

d. No detonation and no penetration

7. If the structure contains multiple separate elements, then a final test must be completed to analyse the subsequent hazards from each element after impact. For example a detonation screen may produce highly damaging secondary fragmentation. Therefore, the structure should be tested with all the additional elements, including screens, supports or any other equipment (surveillance equipment).

**Representative Weapons**

8. The weapons listed in the table below are representative examples and their properties should be used for testing and classification of structures when possible. Deviations, changes or omissions may be necessary but must be documented. Due to the large number of types and manufacturers, actual data may vary from those listed in the table. Technical data are manufacturers' figures except when stated otherwise.

| | **Threat Class** | **Weapon systems examples** |
|---|---|---|
| B9 | | |
| B8 | **Anti-tank** 120/125mm<br>HESH / HEAT | |
| B7 | | |
| B6 | **Advanced ASM**<br>Anti Structure Munitions | Eryx 135mm |
| B5 | **Tandem ASM** | RPG-7 with PG-7VR tandem warhead |
| B4 | **Anti-personnel**<br>Thermobaric charge<br><2.5kg /conventional | RPG-27 Tavolga |
| B3 | **Anti-tank**<br>Shaped charge | RPG-7 with PG-7N warhead<br>RPG-26 Aglen<br>M72 A4 |
| B2 | **40mm Rifle grenade**<br>shaped charge | 40mm x 46 M433 HEDP<br>40mm x 53 M430 HEDP |
| B1 | (reserved) | |

**Table A 2-1:** Representative weapons.

## WEAPON CATEGORY C - INDIRECT FIRE MUNITIONS

### Aim

1. The aim of the test should be to emulate the effect of the detonation of a single warhead, either static or fired directly at the protective structure (dynamic test).

### Failure Modes

2. The failure modes for Weapon Category C are:

   a. Dynamic penetration.

   b. Fragment penetration.

   c. Blast damage.

3. Category C testing considers the envelope of the deployed infrastructure as one entity, with no differentiation between walls and roofs. If elements of a protective structure are intended to both protect against weapon effects as well as being an integral part of the structure itself (ie, walls that both support the roof and protect against weapons, rather than stand-alone blast walls), it is possible that they could defeat a weapon effect (eg, blast) whilst becoming unsafe or failing structurally (ie, there is risk associated with continued occupation of the structure). In this case, the structure should be given a conditional pass (C) and a detailed description of the circumstances/ 'conditions' should be given in the report.

4. If a structure fails as the result of a direct hit it should be assessed to establish the distance from the point of detonation at which it would be effective. This should be recorded as a conditional pass (the condition being that rounds landing closer will cause the structure to fail).

5. The usual type of fuse on an indirect fire munition is intended to detonate on impact and is termed 'super quick'. Munitions which can be fitted with delayed fuses, intended to detonate after total or partial penetration, should be considered as a different weapon type. The dynamic penetration should be established first to determine the position of the munition when it detonates. If delayed fuses are regularly used and the munition can penetrate the protected structure before detonation, the structure should be considered to have failed against that weapon type.

### *Representative Weapons*

| | | **Weapon systems examples** | | **Explosive Mass** | |
|---|---|---|---|---|---|
| C9 | | | | | |
| C8 | Scud | | | | |
| C7 | 333mm Rocket | | | | |
| C6 | 240mm Rocket | | | | |
| C5 | 155mm Artillery<br>122mm Rocket | 155mm M-107 US<br>152mm Sov | 122mm 9M22 Sov<br>(Rocket) | 7.65kg<br>6.62kg TNT | 6.4kg |
| C4 | 120mm Mortar<br>107mm Rocket | 120mm OF-843 Sov<br>107mm Type 63 Chn (Rocket) | 105mm US (Artillery) | 2.68kg TNT<br>1.3kg | 2.3kg Comp B |
| C3 | 82mm Mortar | 82mm M74 Yugo | 81mm M374 US | 0.68kg TNT | 0.93kg Comp B |
| C2 | 60mm Mortar | 60mm M73 Yugo | 60mm M49A4 US | 0.22kg TNT | 0.19kg Comp B |
| C1 | Hand grenade | | | | |

**Table A3-1:** Representative weapons.

## WEAPON CATEGORY D - HIGH EXPLOSIVES

### Aim

1. The aim of the test should be to emulate the effect of the detonation of a single munition placed as close to the structure as possible.

### Failure Mode

2. The only failure mode for weapon category D is blast damage. However there are different hazard effects from blast.

   a. Direct pressure/impulse injuries are covered in Appendix 3 to Annex B.

   b. Secondary effects, including secondary fragmentation, are covered in Appendix 4 to Annex B.

3. There are no specified failure modes for weapon category D as there are too many variables when dealing with blast effects. However the proposed trial method should identify whether the protective structure reduces the blast effects of weapons.

## WEAPON CATEGORY E – MOVING VEHICLES

### Aim

1. The aim of the test should be to emulate the effect of the impact of a single vehicle on the protective structure (dynamic test).

### Failure Mode[2]

2. The failure mode for this category of weapon is vehicle penetration as described in the table at Appendix 5 to Annex B. The standards for conducting the test are given in Reference G, PAS 68 Impact Test Specification for Vehicle Security Barriers, 2010 (extract at Appendix 5 to Annex B).

### Representative Weapons

3. To simplify the data set, the vehicle speed for the test should be 30mph (48 km/h) but additional data may be recorded in the PAS 68 form in the remarks section.

4. The PAS 68 vehicle classifications have been combined with the severity of effect levels in Table A – 1, to derive the table below. Barrier testing for motorcycles is not energy-dependent as for other vehicles and is therefore not covered by the PAS 68. Instead, it is a qualitative measure of the ability of the motorcycle to weave through existing barriers.

| PAS 68 | Examples | STANAG 2280 categories | Remarks |
|---|---|---|---|
| N3 | 32,000kg 4-axle rigid | E5 | |
| N2 | 7,500kg 2-axle rigid | E4 | |
| M2 | 4x4 Single Cab pickup | E3 | |
| M1 | Car | E2 | |
| Motorcycle | Small all terrain bike | E1 | Testing is based on accessibility, (ie, the ability to weave through a chicane/staggered barrier), rather than barrier overmatch (ie, the ability to smash through the barrier). |

**Table A5-1:** Combined PAS 68 and STANAG Weapon Category Severity of Effect table

[2] Reference E: UFC 4-022-02

INTENTIONALLY BLANK

# ANNEX B - CONDUCT OF WEAPON TRIALS

## B.1 Procedures

1. For each hazard there is a set trial to limit any ambiguity of interpretation or transfer of information, as well as setting the worst case scenario. To test the worst case of each hazard, they should be tested separately. For example, the maximum fragment velocity of a weapon is achieved when there is a standoff from the structure. On the other hand, the maximum blast effect is achieved when the weapon is in contact with the structure. Potentially the combined effect may be worse but this is not always the case so separate tests are necessary.

2. The trial procedures are in separate appendixes.

## B.2 Assurance Design Levels.

3. There are four ways to ensure the quality of the data, in order of preference:

    a. **Certified**. Trials by a competent research organisation in accordance with this Standard.

    b. **Tested**. This describes structures tested without the benefit of advanced diagnostic equipment; ‘field tested’ is a term used in the form at Annex C. Field tests will normally be performed with the actual threat weapons (locally available) which may not be specifically listed in the representative weapon types in Annex A. Field tests are useful:

        (1) If the structure has been built using local materials with uncertain properties.

        (2) For non-standard protective structures, whether newly built or pre-existing.

        (3) As a demonstration of the effectiveness of the protection provided by the structure, to increase the confidence of occupants.

    c. **Calculated**. Empirical or mathematical calculations or a design software programme.

    d. **Estimated**. Rule of thumb or interpolation of other results or evidence.

4. There is no requirement to test structures against all listed threats; a reasonable cost/benefit analysis of the possible trials should be undertaken. It is essential to record assumptions and decisions clearly and accurately, as well as stating known risks.

## B.3 Trial report

5. The trial report must contain all the information needed to repeat the test under close to identical conditions. As a minimum, it must contain the following:

| Ser | Detail |
|---|---|
| 1 | Date and place of test |
| 2 | Name and position of the test leader and/or name of the responsible organization |
| 3 | Ambient conditions: Temperature and estimated wind speed |
| 4 | A technical description of the target |
| 5 | Weapon type, version, manufacturer, serial number |
| 6 | Barrel length (*) |
| 7 | Warhead type (*) |
| 8 | Static or live firing (*) |
| 9 | Ammunition type, version, manufacturer, military supplier, LOT |
| 10 | Impact Velocity and Angle of impact |
| 11 | Firing distance |
| 12 | Results |
| (*) Where applicable | |

**Table B - 1:** Trials information.

List of Appendices:

1. Bullets and penetrators (weapon categories A – C);
2. Primary fragmentation (weapon categories A - C);
3. Blast (weapon category D);
4. Secondary Effects (weapon categories A – E);
5. Vehicle Penetration (weapon category E).

**BULLETS AND PENETRATORS** (Weapon categories A – C)

1. This STANAG uses the UK and US Navy definition as shown in Figure B1 – 1: Definition of partial penetration and perforation. In this STANAG the failure mode for penetration is considered to be perforation of the target, as shown in the bottom right of the diagram (inside the dotted line). This is defined as the weapon, or any part of the weapon, passing fully through the target, leaving a clear hole in the target (which may reseal depending on the material).

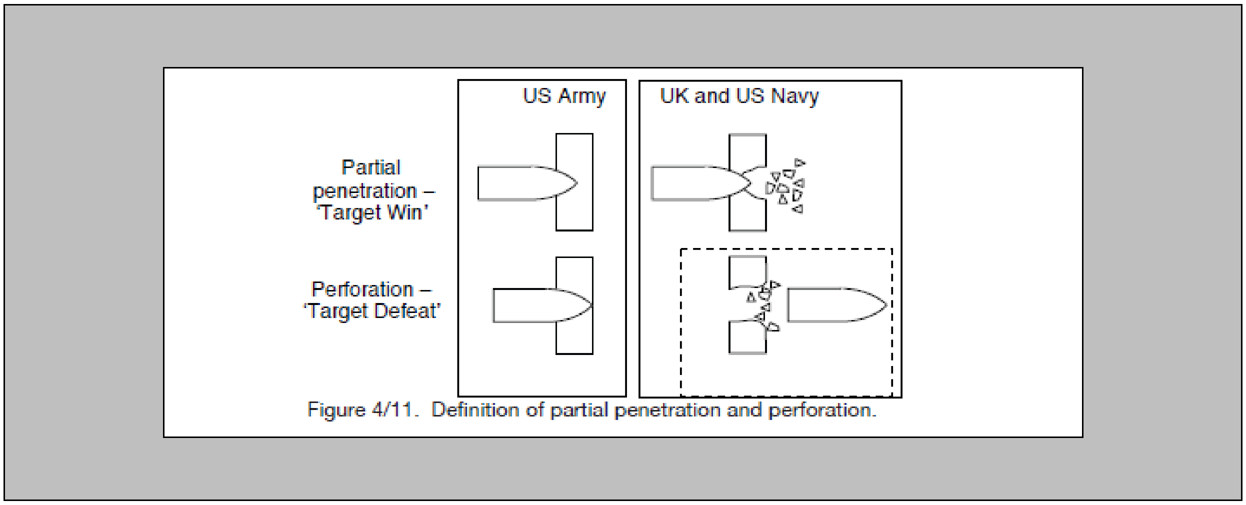



**Figure B1–1**: Definition of partial penetration and perforation

**Recommended Procedure - Bullets**

2. The multi-hit procedures described in Reference F, STANAG 4569, may be used. Alternatively, the following simplified procedure can be followed:

a. Witness plates are placed behind the target with a minimum air gap of 100 mm between the target and the witness plate. Acceptable materials for witness plates are 1.0 mm aluminium, plywood or any weaker material.

b. A group of 3 individual shots is fired at the appropriate range. The distances A-B-C between any 2 hits should be between the limits shown in Table B1 - 1 and Figure B1 - 2.

| Class | Name | Range | Distance between hits (min – max) |
|---|---|---|---|
| A6 | Not included | | |
| A5 | Automatic Cannon | 500 m or less | 100 – 250 mm |
| A4 | Heavy Machine Gun | 200 m “ | 50 – 250 mm |
| A3 | Assault / Sniper Rifle | 30 m “ | 25 – 120 mm |
| A2 | Assault Rifle | 30 m “ | 25 – 120 mm |
| A1 | Assault Rifle | 30 m “ | 25 – 120 mm |

**Table B1–1**: Range and impact pattern for Category A weapons.

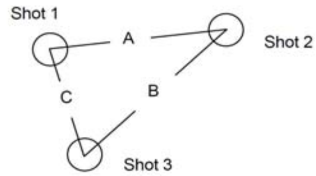



**Figure B1–2**: Impact pattern of individual projectiles.

c. After a series of 3 shots, the target and witness plates should be examined for signs of perforation of the target; it is possible for evidence of perforation of the target only to be visible in the witness plate (eg, a round passing through a sandbag wall but being caught on the witness plate).

d. If there is reasonable doubt whether another test would give the same result or the distances between individual hits are outside the limits, the test should be repeated. The targets and witness plates should be inspected after each series of 3 shots.

**Recommended Procedure - Shaped Charge (Explosively Formed Projectile)**

3. A single static round trial is conducted against the weakest part of the structure; the angle of attack should be perpendicular to the target. The distance from the target should be the designed detonation range of the weapon. Witness plates are placed behind the target with a minimum air gap of 100 mm between the target and the witness plate. Acceptable materials for witness plates are 1.0 mm aluminium, plywood or any weaker material.

4. The target and witness plates should be examined for signs of perforation of the target; it is possible for evidence of perforation of the target only to be visible in the witness plate (eg, a shaped charge jet passing through a sandbag wall but being caught on the witness plate).

**Recommended Procedure - Dynamic Penetrations**

5. Targets are to be placed/orientated to ensure that the maximum warhead penetration may be achieved, which is likely to be perpendicular to the direction of travel of the warhead.

6. The characteristics of representative weapons within a category may vary and are often difficult to obtain. Where possible the specific theatre threat weapon should be used in trials.

7. The preferred order/weapon state for dynamic penetration trials is as follows:

a. **Inert warhead**. An inert warhead is used to establish the penetration of the whole weapon. If the inert warhead does not penetrate the structure it may not be necessary to conduct trials on the same weapon with a delay fuse because it would be expected to detonate or break apart on the external face of the structure.

b. **Surface detonation**. Super quick fuses are intended to detonate on impact. The purpose of this trial is to confirm whether the primary threat posed by the weapon defeats the target. For example, does the shaped jet or fragments perforate the wall? This would usually be a static trial as this would tend to provide statistically more reliable data for the effects of both the shaped charge and fragments. However, the trial could be conducted dynamically to quantify any penetration of the fuse, rocket motor or other parts of the weapon.

c. **Delay fusing.** If an inert warhead is able to penetrate the structure, a trial with a delayed fuse may be conducted to establish the effect of detonation within the wall or inside the structure, depending on the assessed depth of penetration prior to detonation.

8. The distance between the target and the launch point of the warhead in a dynamic trial must be the greatest of the following:

   a. 50m.

   b. The minimum warhead arming distance.

   c. The motor burnout distance (to ensure that the warhead has reached its maximum velocity before impact).

9. The target and witness plates should be examined for signs of perforation of the target; it is possible for evidence of perforation of the target only to be visible in the witness plate (eg, a round passing through a sandbag wall but being caught on the witness plate).

**Additional remarks**

10. The effect a projectile has on a target depends on several factors: the type of target and the material used in construction, as well as the mass, shape, impact velocity and projectile hardness. For instance, with assault rifle ammunition, the (previously) standard NATO 7.62 mm ammunition has nearly twice the muzzle energy of the Russian AK-47 projectile (approximately 3500 J compared with 2000 J) – it is heavier and has a greater velocity. However, the AK-47 projectile has a steel core where the NATO 7.62 uses lead. So, although less energetic, 7.62 x 39 (and also 5.56 x 45) with steel core can in certain cases be more efficient against some materials and personal protection systems.

11. Sometimes there can be confusion regarding the correct designations of various rounds and projectiles because countries / organizations / manufacturers use different naming systems.

12. Technical data, especially muzzle velocity, can vary between different sources of information. The muzzle velocity is determined by the round itself (and the ambient conditions such as temperature) and the barrel length – i.e. the particular weapon. The velocity data provided by a manufacturer will often be results from a specific test or reference weapon and may deviate from the results obtained with a standard (production) weapon. Detailed information about the test conditions are rarely provided by manufacturers, making the proper analysis of results complex.

**Failure Modes**

13. It is essential that the nature of the weapon threat and the interaction with the protected structure is clearly understood to enable appropriate, repeatable and cost effective trials and analysis to be conducted. Describing threat weapons in accordance with the hazards (blast, penetration, fragmentation) which they pose, enables comparisons to be made with similar weapons in different categories (see Table A – 1 in annex A).

14. **Most Likely/Worst Case**. It is important to understand the difference between the severity of the effects caused by weapons in the most likely and worst case scenarios, testing structures accordingly. For example, if the most likely strike angle of a rocket/mortar to a structure is assessed as $45^0$ to $60^0$ and the worst case is considered to be $90^0$, testing should be conducted at $90^0$. Structures designed using worst case test results would also protect against the most likely scenario. Where testing has only been conducted against the most likely scenarios this must be made clear, particularly when data is shared with allies. Worst case scenarios are considered as:

a. For dynamic penetration, the angle of impact must be perpendicular.

b. For blast, it should be the closest point to the target where it would be reasonable that the weapon could detonate. This may be different to both the dynamic penetration and fragmentation distances.

15. **Structural Vulnerable Points**. This STANAG covers a range of structures and threat weapons. As part of the preparation for trials it is necessary to identify what is likely to be the most vulnerable part of the structure against which the trials should be conducted. There is no distinction automatically applied between walls and roofs. A weapon impacting against any part of the wall, including seams and corners if they are considered a weak point, is considered to be a 'fair hit'. A 'fair hit' excludes 'improbable' hits, for example an indirect fire weapon or fragment penetrating a structure through a very small aperture. Windows and doors should be considered with a 'fair hit' policy and the weapon should be initiated on the external envelope of the structure in trials. If doors and windows are used, their assessment should be separate from that of the wall and a note to that effect must be included on the form at Annex C.

16. **Blast**. When conducting blast trials against structures it is essential to consider the entry and exit of blast waves through apertures in the structure. It is essential to state what criteria has been used when sharing information.

**PRIMARY FRAGMENTATION** [1] (weapon categories A - C)

**Recommended procedures**

1. To minimise any ambiguity the worst case scenario must be used in the trial, although this is acknowledged to be a cautious approach. If resources allow, the trial could be repeated for the most/more likely scenarios particularly if the structure failed in the worst case scenario. This will help to establish the distance/angle of incidence conditions for a weapon at which the structure provides effective protection. For fragmentation, the orientation of the warhead to and distance from the target should result in the highest speed and density of fragments; this may be different to the angle of attack to achieve dynamic penetration.

2. The procedure for trials of protective structures against fragment perforation is to detonate a single, static live shell / grenade / warhead adjacent to the target, with the distance and height determined as follows:

    a. **Distance**. The distance from shell / grenade / the warhead to the target should be great enough to minimise blast effects as well as to allow the fragments to reach their maximum velocity (therefore maximum penetration potential), yet small enough to ensure a sufficient number of fragments hit the target. The correct distance will depend on the size of the target; usually the minimum will be *10 calibres* and the maximum 5m as shown in the figure below.

    b. **Height**. The shell / grenade / warhead should be fixed at a height to allow the maximum number of fragments to hit the target. Most fragments are ejected radially (perpendicular to the long axis), with a slight adjustment for the Taylor angle and casing geometry. The centre of the warhead should be aligned to the mid-point of the vertical axis of the target and then shifted 10% of the firing distance in the direction of the fuse / booster. (Example: If the fuze is in the nose and the nose is up – raise the warhead an extra 100 mm if the firing distance is 1 m).

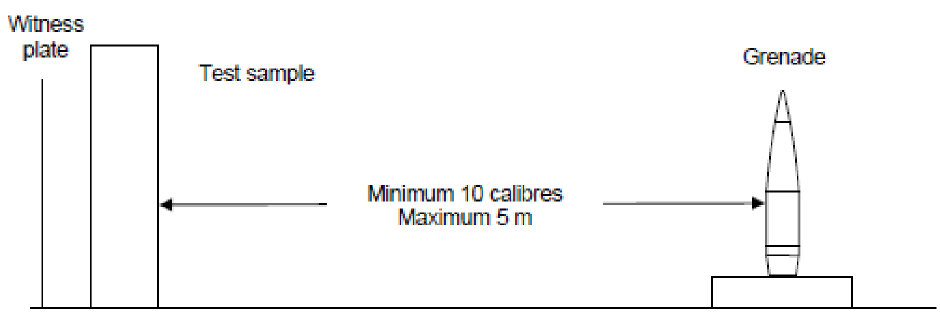



**Figure B2-1:** Layout for fragmentation trials.

    c. **Assessment of results**. One or more witness plates should be placed behind the target with a minimum air gap of 100 mm; acceptable materials for witness plates are 1.0 mm aluminium, plywood or any weaker material. Penetration of fragments will be confirmed by examining the rear of the target as well as the witness plate. The structure will be considered to have failed if any penetration of the target occurs.

[1] Primary fragmentation is fragmentation of the warhead; secondary fragmentation is fragmentation of the target/structure or material from other sources thrown out as a result of the blast.

**BLAST** (weapon category D)

1. Blast is a complex loading mechanism which is difficult to define for all situations. It is intended that the procedures described in this appendix will enable all blast tests to be conducted in a similar way and the correct measurements to be taken to allow comparisons to be made. As breaching is an instant failure, the test is designed to determine the maximum range at which breaching occurs (or minimum range at which breaching does not occur). A comparison is then made between the blast pressure with the benefit of a protective structure (protected pressure) and the pressure without a protective structure (unprotected pressure). The percentage reduction in the threshold range can be calculated (ie, how much closer can the weapon be detonated without causing injuries if there is a protective structure). 100% reduction means that the weapon can detonate in contact without causing casualties, whilst 0% reduction means that the protective structure does not mitigate the effects of the blast wave at all.

**Type and Size of Explosive**

2. It is important to ensure that the same effect is achieved in similar trials with different explosives so that accurate comparisons can be made. Therefore the TNT equivalent mass, found in table B3 - 1 or B3 - 2 (from Reference D), must be used; all references to explosive mass in this STANAG are the TNT equivalent mass.

3. The charge geometry should be approximately uniform and no single dimension should be more than 50% greater than any other dimension; semi-hemispherical is acceptable.

**Preparation of Trial**

4. Protective structures are likely to move under blast loading; this is acceptable but it is important to record details of this movement including, where possible, the maximum deflection of the wall whilst subjected to the blast impulse as well as the final displacement. Reference points must be established away from the target, outside the area likely to be affected by detonation of the weapon (eg, blast, fragments), to enable measurements of deflection to be taken relative to these fixed points.

5. All charges are to be placed on the ground. Where possible, the hardness of the ground at the trial site is to be at least CBR 5% (equivalent to compacted graded material) in order to ensure that the explosive energy is not absorbed by the ground.

**Significant Weapon-to-Structure Distances**

6. The following distances should be recorded:

   a. **Maximum Breaching Range (m).** The maximum breaching range is the distance between the weapon and the structure at which the blast wave will just cause a breach or other failure in the structure (beyond this distance the structure will not be breached). Breaching is considered to have occurred when a potentially dangerous effect penetrates the structure and/or it fails in an unsafe manner (ie, fails in such a way that the collapsing structure itself presents a risk of injury). This is a measure of distance in metres; there is no pass or fail distance.

   b. **Higher Threshold Range (m).** The higher threshold range is the distance between the weapon and the person at which there is a 1% likelihood of a fatal injury caused by lung damage due to the pressure and impulse of the blast wave.

c. **Lower Threshold Range (m).** The lower threshold range is the distance between the weapon and the person at which the pressure from the blast will cause injuries (eardrum rupture), but is highly unlikely to cause any fatalities.

| Explosive | Density Mg/m$^3$ | Equivalent Mass for Pressure | Equivalent Mass for Impulse | Pressure Range MPa |
|---|---|---|---|---|
| Amatol (50/50) | 1.59 | 0.97 | 0.87 | NA[1] |
| Ammonia Dynamite (50 percent Strength) | NA[1] | 0.90 | 0.90[2] | NA[1] |
| Ammonia Dynamite (20 percent Strength) | NA[1] | 0.70 | 0.70[2] | NA[1] |
| ANFO (94/6 Ammonium Nitrate/Fuel Oil) | NA[1] | 0.87 | 0.87[2] | 0.03-6.90 |
| AFX-644 | 1.75 | 0.73[2] | 0.73[2] | NA[1] |
| AFX-920 | 1.59 | 1.01[2] | 1.01[2] | NA[1] |
| AFX-931 | 1.61 | 1.04[2] | 1.04[2] | NA[1] |
| Composition A-3 | 1.65 | 1.09 | 1.07 | 0.03-0.35 |
| Composition B | 1.65 | 1.11<br>1.20 | 0.98<br>1.30 | 0.03-0.35<br>0.69-6.90 |
| Composition C-3 | 1.60 | 1.05 | 1.09 | NA[1] |
| Composition C-4 | 1.59 | 1.20<br>1.37 | 1.19<br>1.19 | 0.07-1.38<br>1.38-20.70 |
| Cyclotol (75/25 RDX/TNT)<br>(70/30)<br>(60/40) | 1.71<br>1.73<br>1.74 | 1.11<br>1.14<br>1.04 | 1.26<br>1.09<br>1.16 | NA[1]<br>0.03-0.35<br>NA[1] |
| DATB | 1.80 | 0.87 | 0.96 | NA[1] |
| Explosive D | 1.72 | 0.85[2] | 0.81 | 0.01-0.30 |
| Gelatin Dynamite (50 percent Strength) | NA[1] | 0.80 | 0.80[2] | NA[1] |
| Gelatin Dynamite (20 percent Strength) | NA[1] | 0.70 | 0.70[2] | NA[1] |
| H-6 | 1.76 | 1.38 | 1.15 | 0.03-0.70 |
| HBX-1 | 1.76 | 1.17 | 1.16 | 0.03-0.14 |
| HBX-3 | 1.85 | 1.14 | 0.97 | 0.03-0.17 |
| HMX | NA[1] | 1.25 | 1.25[2] | NA[1] |
| LX-14 | NA[1] | 1.80 | 1.80[2] | NA[1] |
| MINOL II | 1.82 | 1.20 | 1.11 | 0.02-0.14 |
| Nitrocellulose | 1.65-1.70 | 0.50 | 0.50[2] | NA[1] |
| Nitroglycerine Dynamite (50 percent Strength) | NA[1] | 0.90 | 0.90[2] | NA[1] |
| Nitroguanidine (NQ) | 1.72 | 1.00 | 1.00[2] | NA[1] |
| Nitromethane | NA[1] | 1.00 | 1.00[2] | NA[1] |

[1]NA - Data not available [2]Value is estimated

**Table B3-1:** Equivalent TNT masses for airblast in free-air (1 of 2)

| Explosive | Density Mg/m³ | Equivalent Mass for Pressure | Equivalent Mass for Impulse | Pressure Range MPa |
|---|---|---|---|---|
| Octol (75/25 HMX/TNT)<br>(70/30) | 1.81<br>1.14 | 1.02<br>1.09 | 1.06<br>1.09 [2] | NA[1]<br>0.01-0.30 |
| PBX-9010 | 1.80 | 1.29 | 1.29 [2] | 0.03-0.21 |
| PBX-9404 | 1.81 | 1.13<br>1.70 | 1.13 [2]<br>1.70 | 0.03-0.69<br>0.69-6.90 |
| PBX-9502 | 1.89 | 1.00 | 1.00 | NA[1] |
| PBXC-129 | 1.71 | 1.10 | 1.10 [2] | NA[1] |
| PBXN-4 | 1.71 | 0.83 | 0.85 | NA[1] |
| PBXN-107 | 1.64 | 1.05 [2] | 1.05 [2] | NA[1] |
| PBXN-109 | 1.67 | 1.05 [2] | 1.05 [2] | NA[1] |
| PBXW-9 | NA[1] | 1.30 | 1.30 [2] | NA[1] |
| PBXW-125 | 1.80 | 1.02 [2] | 1.02 [2] | NA[1] |
| Pentolite (Cast) | 1.64<br>1.68<br>NA[1] | 1.42<br>1.38<br>1.50 | 1.00<br>1.14<br>1.00 | 0.03-0.69<br>0.03-4.14<br>0.69-6.90 |
| PETN | 1.77 | 1.27 | 1.27 [2] | 0.03-0.69 |
| Picrotol (52/48 Ex D/TNT) | 1.63 | 0.90 | 0.93 | 0.03-4.10 |
| RDX | NA[1] | 1.10 | 1.10 [2] | NA[1] |
| RDX/Wax (98/2) | 1.92 | 1.16 | 1.16 [2] | NA[1] |
| RDX/AL/Wax (74/21/5) | NA[1] | 1.30 | 1.30 [2] | NA[1] |
| TATB | NA[1] | 1.00 | 1.00 [2] | NA[1] |
| Tetryl | 1.73 | 1.07 | 1.07 [2] | 0.02-0.14 |
| Tetrytol (75/25 Tetryl/TNT) | 1.59 | 1.06 | 1.06 [2] | NA[1] |
| TNETB | 1.69 | 1.13 | 0.96 | 0.03-0.69 |
| TNETB/AL (90/10)<br>(78/22)<br>(65/35) | 1.75<br>1.18<br>1.23 | 1.23<br>1.32<br>1.38 | 1.11<br>1.32 [2]<br>1.38 [2] | 0.03-0.69<br>NA[1]<br>NA[1] |
| TNT | 1.63 | 1.00 | 1.00 | Standard |
| Torpex | 1.85 | 1.23 | 1.28 | 0.01-0.30 |
| Tritonal (80/20 TNT/AL) | 1.72 | 1.07 | 0.96 | 0.03-0.69 |

[1]NA - Data not available [2]Value is estimated

**Table B3-2:** Equivalent TNT masses for airblast in free-air (2 of 2)

**Explosive Content of Weapons**

7. Some munitions may not be made exactly in accordance with manufacturers published specifications and there could be variations in the explosive quantity. In addition, it is difficult to assess either whether the explosive in a weapon has fully detonated or to measure the size of an explosion to confirm that the weapon actually contained the specified amount of explosive. Therefore, when testing weapons where it is not possible to confirm the explosive content, pressure and impulse values must be taken at set ranges and compared to the data in Table B3 – 3, which has been derived from research programmes.

| Category | TNT equivalent (Kg) | Higher Threshold | | | Lower Threshold | | |
|---|---|---|---|---|---|---|---|
| | | Range (m) | Pressure (psi) | Impulse (psi-msec) | Range (m) | Pressure (psi) | Impulse (psi-msec) |
| D9 | 5000 | 39.3 | 30 | 291.00 | 97.6 | 5 | 130.50 |
| D8 | 1000 | 23.0 | 30 | 170.20 | 57.0 | 5 | 76.29 |
| D7 | 250 | 14.5 | 30 | 107.20 | 36.0 | 5 | 48.06 |
| D6 | 50 | 8.3 | 31 | 63.54 | 21.0 | 5 | 28.10 |
| D5 | 10 | 4.4 | 39 | 40.81 | 12.3 | 5 | 15.44 |
| D4 | 2 | 2.3 | 50 | 26.44 | 7.2 | 5 | 9.61 |
| D3 | 1 | 1.7 | 55 | 21.82 | 5.7 | 5 | 7.63 |
| D2 | 0.5 | 1.3 | 64 | 18.43 | 4.5 | 5 | 6.06 |
| D1 | 0.1 | 0.6 | 100 | 12.90 | 2.6 | 5 | 3.54 |

**Table B3–3**. TNT equivalent (kg), as a hemispherical blast (placed near to the ground)

**Measurements**

8. The principal measurements to be recorded from such trials are the charge mass and blast pressure/impulse at various distances from the detonation. Pressure gauges should be set at 1.5m above the ground / finished floor level, which is taken to be the representative height of a standing man.

9. For maximum effect the weapon-to-structure distance should be the maximum breaching range unless this is not suitable, for example if the specified design stand-off distance is greater. In this case, the weapon-to-structure distance must be between the maximum breaching range and the higher threshold range. This can be calculated from table B3 – 3 which shows, for a given weapon category/TNT equivalent mass of the weapon (from the manufacturers details – see paragraph 7), the higher and lower threshold ranges in metres. Pressure gauges should be set at these distances so that the actual pressure/impulse measurements for different weapons can be recorded and compared with the expected values given in the table.

10. If the pressure and impulse measurements are below the values shown in table B3 – 3 for the weapon category, it is likely that the explosive content of the weapon was less than that given in the manufacturer's specification. Therefore it should be assumed that, for weapons of that type containing the correct amount of explosive, the actual higher and lower threshold distances are less than the figures given in the table; there will be a greater probability of casualties/fatalities unless additional mitigation measures are taken (eg, more protection or greater separation).

11. If the target includes protected enclosed spaces, for example a Hardened Accommodation Bunker, then additional gauges must be placed inside the structure. If possible, use blast

modelling to assess the locations of maximum pressure, but as a general rule gauges should be placed:

a. At the entrance.

b. In the centre of enclosed spaces.

c. In the centre of an enclosed wall.

d. In one of the corners.

e. In the centre of corridors.

12. Other measurements that maybe useful to enhance understanding and inform future research are:

a. Pressure and impulse on the front surface of the target.

b. Pressure and impulse on the rear surface of the target.

**Calculations and interpretation**

13. **Assumptions**:

a. **Trial/event conditions** (these assumptions describe the context for trials/ a 'live' situation when a protective structure is subjected to a 'weapon event'):

(1) The worst case is assumed to be a man standing in the open, without body armour [note: even with body armour there is little, if any, difference to calculations/ results];

(2) The blast wave is considered to be hemispherical (though it should be noted that the charge shape does not need to be hemispherical for this assumption to be reasonable);

(3) A conversion factor of 1.8 must be used to change from a spherical to hemispherical blast form;

(4) The average man weighs = 70.3kg;

(5) Ambient temperature = $20^0$C;

(6) Ambient pressure = 1 bar.

b. **Calculations**. It is assumed that detailed calculations and interpretation will be done by technically qualified/experienced personnel with access to the CONventional WEPons modelling tool CONWEP[1]. As such, the equations used to calculate 'blast effects' have not been included in the ATP.

14. **Interpretation**. The different effects that arise from an explosion/weapon detonation and their interaction with structures and people are difficult to separate from each other, making proper analysis of an event and the impact of these effects very complex. However, it is essential to understand the various mechanisms involved, in order to mitigate each as much as possible, as well as to ensure that no protective measure exacerbates the impact

[1] CONWEP contains empirical data to plot curves of overpressure against impulse.

of another effect (eg, injury from secondary fragments from a protective wall). Free-field detonation trials allow the blast effects to be examined in isolation and appropriate comparisons made.

15. **Nomenclature**. The symbols used in the diagrams have the following meanings:

a. Pressure:

(1) $P_s$ = measured pressure (unprotected);

(2) $P_p$ = measured pressure (protected);

(3) $P_{sh}$ = higher threshold pressure (unprotected);

(4) $P_{sl}$ = lower threshold pressure (unprotected);

(5) $P_{ph}$ = higher threshold pressure (protected);

(6) $P_{pl}$ = lower threshold pressure (protected).

b. Range/distance between detonation and person/pressure gauge (from Table B3 – 3):

(1) R = Range/distance (unprotected);

(2) $R_p$ = Range/distance (protected);

(3) $R_l$ = Lower threshold range;

(4) $R_h$= Higher threshold range;

(5) $R_r$ = Range/distance (reduced);

(6) $R_{rl}$ = Reduced lower threshold range;

(7) $R_{rh}$= Reduced higher threshold range.

c. Weight of explosive

(1) W = Explosive weight (unprotected).

(2) $W_p$ = Explosive weight (protected).

(3) $W_r$ = Explosive weight (reduced).

d. Z = Scaled distance, used against numerical analysis 'Kingery and Bulmarsh' graphs.

16. **Explosive Weight - Unprotected[2] (W).** With the measured pressure (unprotected) ($P_{sl}$ and $P_{sh}$) and impulse at the distances $R_l$ and $R_h$ given in Table B3 - 3, use the CONWEP to calculate the actual explosive weight (W) to be used in the trial. This should be done for both the higher and lower threshold distances and the lowest value of W should be used in future calculations and trials. This will determine whether enough explosive has fully detonated and that the required (or greater) pressure has occurred. Even if the pressure is less than the expected value, the reduction in effect (see below) can still be determined;

[2] Measurement of the explosive effect without a protective structure.

however the maximum breaching range and the lower threshold range will be underestimated.

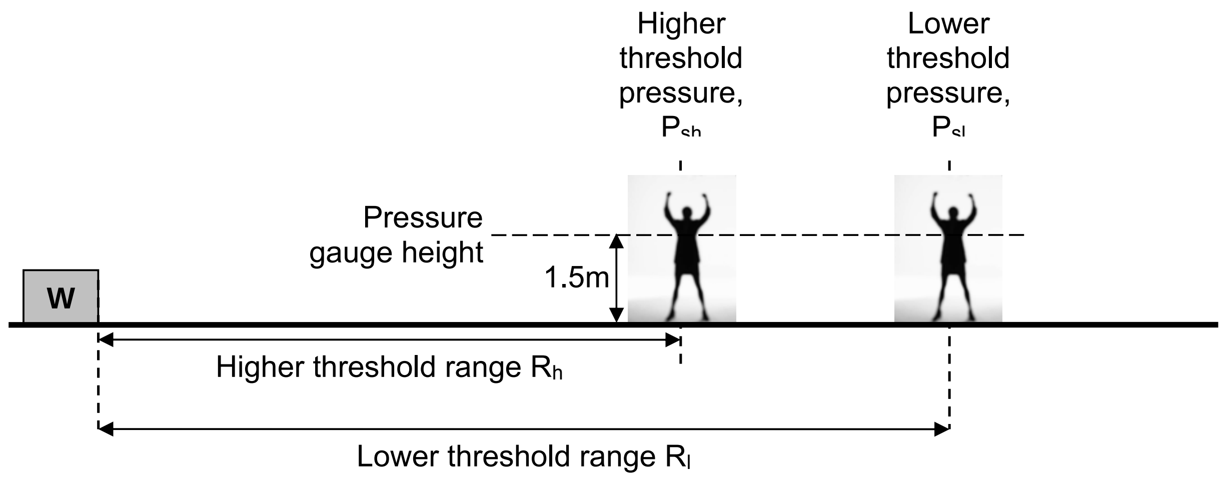



**Figure B3–1**: Unprotected threshold ranges.

17. **Explosive Weight – Protected[3] ($W_p$).** Using $P_p$, the measured pressure (protected) recorded behind the protecting structure, and R, the distance given in Table B3 - 3, calculate $W_p$ (which will be larger than W), the actual hemispherical charge size, using the equation below. This is the charge size, in a free-field explosion, that would give the same pressure at the same distance as the charge size W in an unprotected trial.

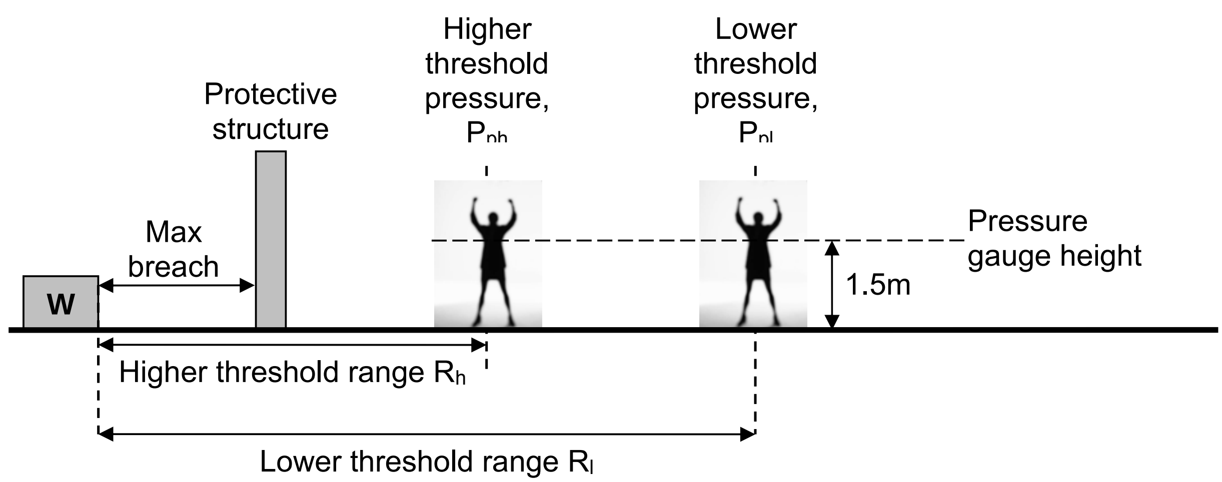



**Figure B3–2**: Protected threshold ranges.

[3] Measurement of the explosive effect with a protective structure.

18. **Reduction in Effect**. It is useful to be able to describe the effectiveness of protective structures, in terms of the reduction in threshold range, as a % of the unprotected threshold range. The reduction in effect of the blast, achieved by the protective structure, is graded as follows:

a. **60% – 100% - Good**. 100% reduction in blast effect means that the weapon can be detonated in contact with the structure without any effects being felt on the opposite side.

b. **20% – <60% - Acceptable**. This indicates that the protective structure provides significant benefit.

c. **0% - <20% - Limited benefit**. There is little, if any, reduction in blast damage.

d. **< 0% – no benefit**. If personnel would be injured by a given explosion/detonation without protection, they will be injured to the same extent by the same explosion/detonation even if there is a protective structure. In the worst case, the structure could have a negative effect by causing secondary injury (eg, crushing by collapsing structure) even if the blast pressure does not injure the person directly.

19. **Reduced Threshold Range - Protected ($R_p$)**. The Reduced Threshold Range (protected) ($R_p$) is the point at which the same pressure impulse, or damage, arises from a given detonation with protection as occurs in an unprotected/ free-field detonation at range R. In order to examine the blast effects at the reduced threshold range in isolation (ie, without a protective structure) it is necessary to reduce the weight of explosive used in the trial ($W_r$) as well as reducing the range to $R_p$, so that the higher threshold pressure (protected) ($P_{ph}$) is equal to the higher threshold pressure (unprotected) ($P_{sh}$) (and/or the same applies for the pressure at the lower threshold range). The reduced range, $R_p$, cannot be below the maximum breaching range.

20. **Reduction in Effect (%).** The effective reduction in the threshold distance, when using a protective structure, can be expressed as a percentage of the unprotected threshold distance, using the equation below:

$$\text{Reduction in Effect (\%)} = \frac{R - R_p}{R} \times 100$$

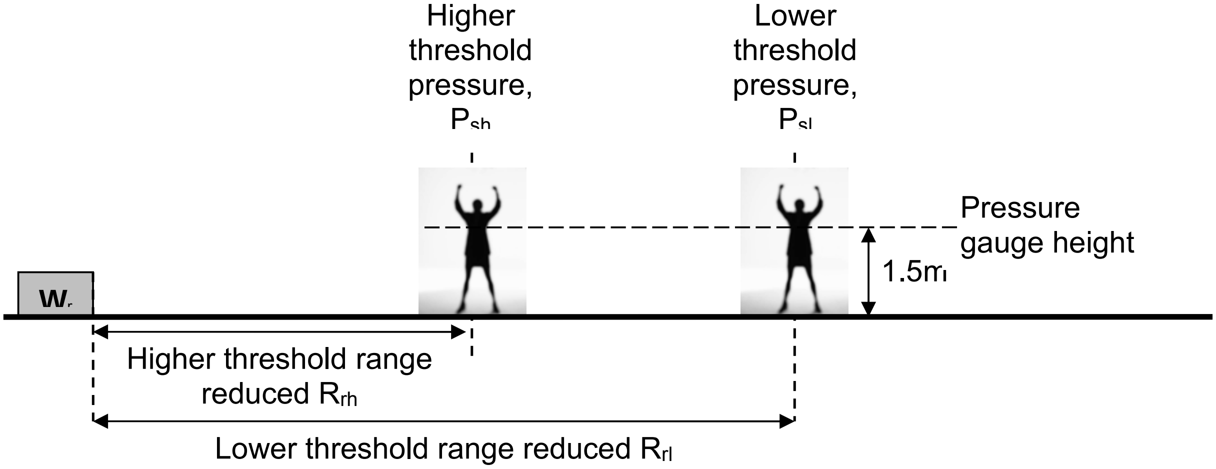



**Figure B3–3**: Reduced range.

**Pressure/Impulse Survival/ Injury Damage Threshold Charts**

(These diagrams have been included to assist engineers to explain to commanders that blast can have a range of effects, depending on more than one variable. It is not possible to state that 'in a given position there will (or will not) be injuries caused'. It is not intended that they should be used to interpret/ interpolate detailed results.)

21. **Human Body.** The measure of damage to the human body from blast can be interpolated from the diagram published by Bowen et al in 1968, which has been taken from Reference D. The diagram below shows the survival rate for combinations of pressure and impulse resulting from an explosion. For a set explosive weight, the damage is dependent on range from the blast. It is possible to calculate the range for a given blast at which injuries or fatalities will occur.

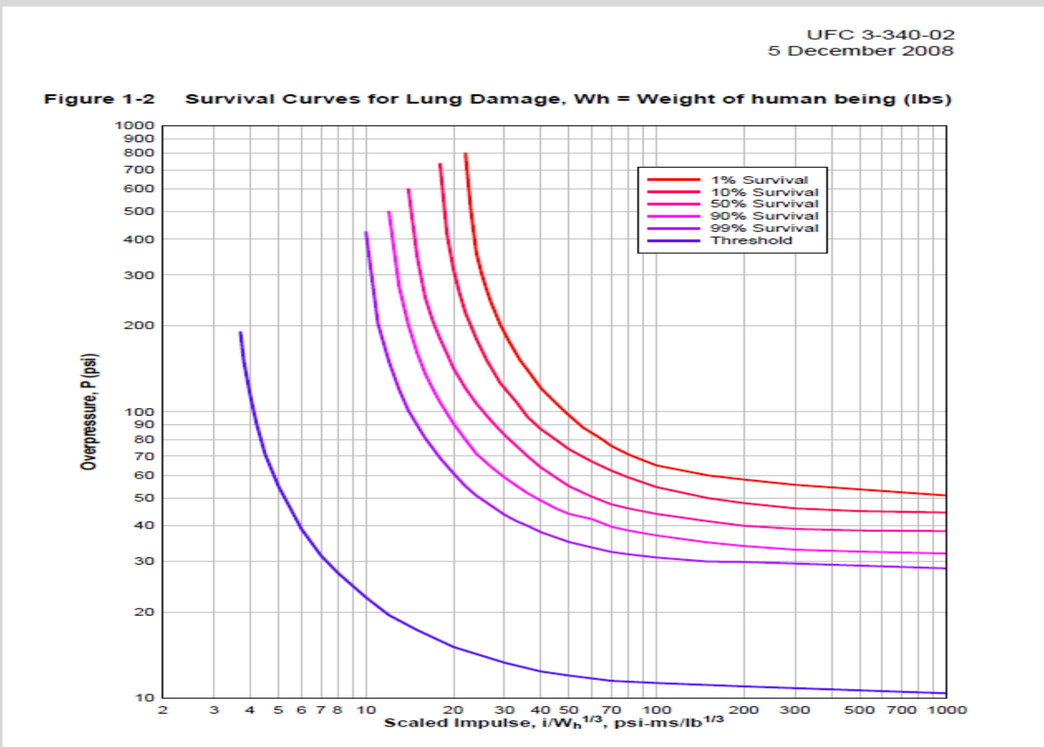



**Figure B3-4:** Survival rate for combinations of pressure and impulse.

22. **Human Ear.** The eardrum is both stiffer and more brittle than other body parts, making it vulnerable to much lower pressures. Because of this, the duration of a blast wave has little influence on damage and PI curves are linear for charges greater than 500g. Commonly accepted eardrum damage thresholds are given in figure 1.3 of Reference D. Note that these pressures apply to a single blast and that they represent a 1% probability of injury. Furthermore, they are for the general case in which it is unknown from which direction the blast wave will hit the body.

| Eardrum damage | Threshold value in 1% of humans |
|---|---|

| | |
|---|---|
| Major – total disruption | 10 psi / 69 kPa |
| Moderate – large tears | 7 psi / 48 kPa |
| Minor – small tears | 4 psi / 28 kPa |

**Table B3–4**: Eardrum damage thresholds

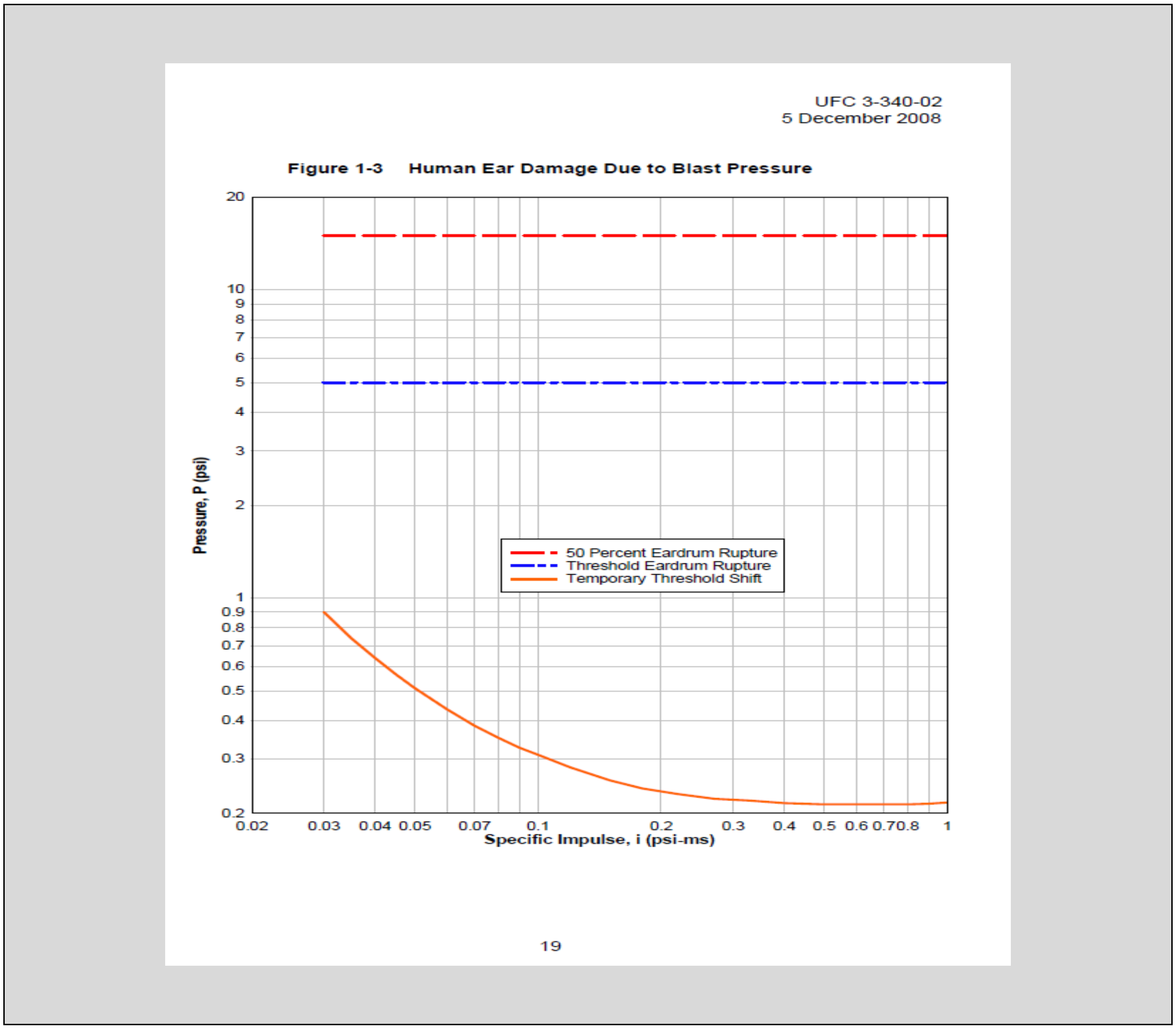



**Figure B3-5:** Eardrum damage due to blast.

**SECONDARY EFFECTS** (weapon categories A – E)

There may be a number of secondary effects from different hazards. Additional trials are not required specifically to investigate secondary effects, however observations/ measurements should be made during other trials to gather data. Significant secondary effects may not mean that the structure is assessed as having failed, but the measurements are required in order to quantify the risk. The following should be observed/ measured:

1. **Spalling**. If any part of the rear of the target is missing it should be recorded as possible spalling;

2. **Movement**. Any movement of the target must be recorded**;**

3. **Secondary Fragments**. The size, distance travelled and, if possible, the speed of any secondary fragments from the structure should be recorded, in order to assess whether any would have the potential to cause injury or death;

4. **Damage due to failing structure**. Any failure of a structure (eg, collapsing roof) that could cause additional injury;

5. **Fire**. If the protective structure catches fire, such that it could cause injuries. Consideration might need to be given to incorporating fire retardant measures into the structure.

**VEHICLE PENETRATION** (weapon category E)

1. Vehicle penetration definitions are stated in Reference G and failure modes have been taken from Reference F, transformed into the PAS 68 classifications in the table below. The picture on page B5 - 4 shows how penetration is measured relative to a common reference point on different vehicles (car and 4x4 single cab pick-up ‘A’ pillar/ leading edge of goods vehicle load platform).

| Criteria | Vehicle Penetration Definition | Pass / Fail |
|---|---|---|
| **Unlimited** | Vehicle is not stopped by barrier | Fail |
| **P50** | Vehicle is stopped within 15.4m (50 ft) beyond the barrier | Conditional |
| **P20** | Vehicle is stopped within 6.2m (20 ft ) beyond the barrier | Conditional |
| **P3** | Vehicle is stopped within 0.9m (3 ft) beyond the barrier | Pass |

**Table B5–1**: Vehicle Penetration Failure Criteria

**Recommended procedures - Extract from PAS 68**

**5 Vehicle impact assessment**

**5.1 Performance requirements**

When tested using the vehicle impact method the vehicle security barrier shall bring to rest or redirect and contain an impacting vehicle on the approach side of the barrier.

Damage to, or movement of the vehicle security barrier shall be recorded and reported. The measurement shall record a maximum horizontal opening measured 600 mm above finished ground level.

*NOTE 1 A gap of 1.2 m or more measured at 600 mm above finished ground level is deemed to be encroachable by a second vehicle.* If the vehicle security barrier consists of bollards (active or passive), all bollards shall meet the performance requirements individually. Movement, lateral and rotational, of any foundation, and/or the bollard, shall be recorded and reported (see Figure 1).

*NOTE 2 If the vehicle security barrier is also intended to resist access by pedestrian intruder, then following a vehicle impact, the barrier should be assessed using the test block shown in Figure 2. The test block should be offered to the opening formed in the vehicle security barrier by the impact to assess whether or not the full length of the block can pass axially through the opening; the result should be reported in the ‘Observations’ section of the Test Report (see* ***5.3.3*** *and* ***C.6****).*

5.2 Test methodology

5.2.1 Principle

The client shall specify the impact criteria of the product, against which they wish it to be tested. A vehicle conforming to one of the specifications outlined in Table 3 shall be impacted at a known speed into the vehicle security barrier under test to determine its impact resistance and subsequent classification.

5.2.2 Test facility

**5.2.2.1** The test facility shall be flat with a gradient not exceeding 2.5% in any plane. It shall be of sufficient size to enable the test vehicle to be accelerated up to the required speed and controlled so that its approach to the test item is stable.

**5.2.2.2** The area around the test item and the foundation to the test item shall have a level surface and shall be clear of standing water (e.g. puddles), ice or snow at the time of the test.

**5.2.2.3** To enable the test vehicle exit characteristics to be evaluated, the firm surface shall extend not less than 25 m beyond the rear of the original vehicle security barrier.

**5.2.2.4** Appropriate measures shall be taken in order to minimize dust or water spray generation from the test site or the test vehicle during the impact test so that photographic high-speed film and video graphic records are not obscured.

**5.2.2.5** The test site shall be marked by a suitable means to indicate the rear face of the test item

Table 3 **Specification for test vehicles**

| **Test vehicle classification** [A] | **Car** | **4×4 single cab pick-up** | **Day cab vehicles** | | | |
|---|---|---|---|---|---|---|
| | | | **3 500 flat bed (RWD)** [B] | **7 500 2-axle rigid** | **18 000 2-axle rigid** | **32 000 4-axle rigid** |
| **UN ECE International vehicle classification** | **M1** | **M2** | **N1** | **N2** | **N3** | **N3** |
| Minimum unladen mass (kg) | 1 200 | 1 675 | 1 900 [C] | 3 850 [C] | 6 800 [C] | 10 500 |
| Maximum ballast (kg) [D] | 300 | 700 | 1 900 | 2 950 | 150 | 19 000 |
| Inertial test vehicle mass(kg) | 1 500 | 2 500 | 3 500 | 6 800 | 6 800 | 30 000 |
| **Tolerance (kg)** | ± 50 | ± 50 | ± 100 | ± 100 | ± 140 | ± 590 |
| Maximum cargo, including dummy (75 kg) if required by client | 75 | 75 | 75 | 700 | 700 | 75 |
| Test vehicle mass (kg) | 1 500 | 2 500 | 3 500 | 7 500 | 7 500 | 30 000 |
| **Tolerance (kg)** | ± 50 | ± 50 | ± 150 | ± 150 | ± 150 | ± 590 |
| **Overall vehicle length (m)** | 4 500 | 4 900 | 6 200 | 7 612 | 9 557 | 10 240 |
| **Tolerance (mm)** | ± 360 | ± 320 | ± 380 | ± 1 522 | ± 1 911 | ± 500 |
| Wheel base (between extreme axles) | 2 700 | 2 900 | 3 805 | 4 310 | 590 | 6 500 |
| **Tolerance (mm)** | ± 540 | ± 580 | ± 710 | ± 830 | ± 1 250 | ± 200 |

[A] The types of vehicle are illustrated in Figure 4.
[B] RWD = rear wheel drive.
[C] The minimum unladen mass shall be at least 55% of inertial test mass for 2-axle rigid vehicles.
[D] The maximum ballast includes measuring and recording equipment, if requested. Such equipment should comply with the requirements of BS EN 1317-1, clause 6.2.

5.2.3 **Specimen preparation**

**5.2.3.1** Photographs shall be taken to record the preparation and installation of the barrier and its foundation.

**5.2.3.2** The test item shall be mounted and located in or on the test bed in accordance with the manufacturer's installation instructions.

**5.2.3.3** The test item shall be installed to the specified height above ground level to the manufacturer's installation instructions.

**5.2.3.4** If the test item is a direction sensitive product, it shall have a mark visible when installed to indicate the plane designed to receive the impact. The relationship between the mark and the plane of impact shall be identified in the test item drawing.

*NOTE The alignment of the barrier will need to be detailed in the installation instructions.*

### 5.2.4 Test vehicle preparation

**5.2.4.1** The test vehicle shall be a production model representative of the current traffic, having characteristics and dimensions within the vehicle specifications given in Table 3.

**5.2.4.2** The test vehicle shall be not more than 10 years old except for the 30 000 kg vehicles, which shall be no more than 15 years old.

**5.2.4.3** The tyres shall be inflated to the manufacturer's recommended pressures.

**5.2.4.4** The condition of the test vehicle shall be such as to satisfy the requirements for the issue of a certificate of road worthiness with respect to the following:

a) tyres;

b) suspension;

c) wheel alignment; and

d) bodywork.

The vehicle shall be clean and any deposits that might cause dust on impact shall be removed prior to testing.

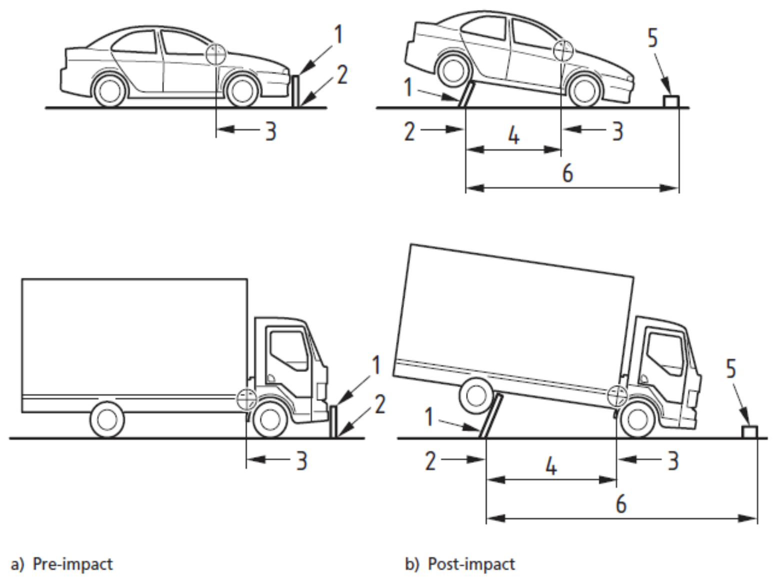
**5.2.4.5** The vehicle shall not be redirected by external (the test facility) control of the steering or restrained (for example, by engine power or by braking) during impact or after the impact point whilst the vehicle is within a distance of 25 m of the original back face of the barrier (unless the test vehicles poses a safety or operational risk).

**5.2.4.6** All ballast shall be fixed to the vehicle in such a way as not to exceed the manufacturer's specifications for distribution of weight at the vehicle axles. The distribution of cargo shall maintain these conditions.

**5.2.4.7** When preparing a goods vehicle for test, the position of the leading edge of the load platform with a quartered target marker shall be marked. This position shall be duplicated with a clear mark on the chassis in case the load platform moves relative to the chassis (see Figures 3 a) and 3 b)). Additional marks may be required in order to provide reference points for measurement purposes.

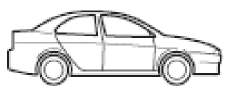
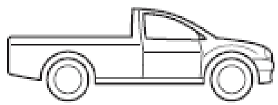
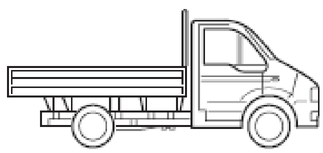
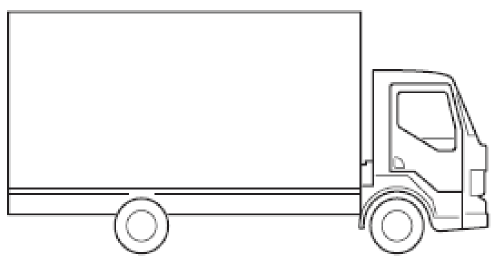
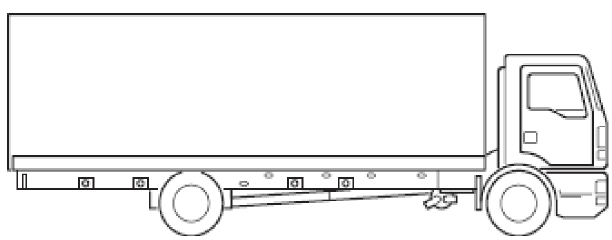
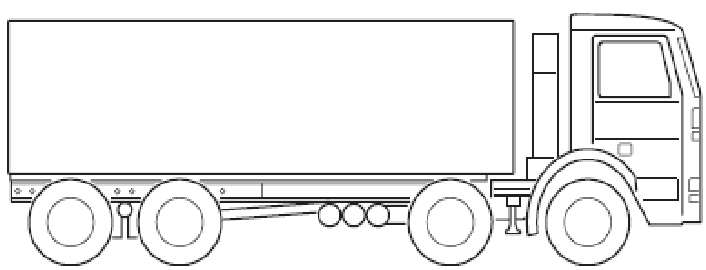
*NOTE For other vehicles, mark the base of the 'A' pillar with a quartered target marker*. Figure 3 a) and 3 b) test vehicle in the pre-impact condition and the post-impact condition respectively, for illustration purposes.

Figure 3 Test vehicle's impact condition




Key:
1 Vehicle security barrier / test item
2 Rear face of vehicle security barrier / test item
3 Car and 4x4 single cab pick-up 'A' pillar / leading edge of goods vehicle load platform
4 Penetration distance
5 Major debris
6 Dispersion distance

Figure 4 **Vehicle classifications – Illustrations**

| Type of test vehicle | UN ECE International vehicle classification | Illustration |
|---|---|---|
| Car | M1 |  |
| 4x4 single cab pick-up | M2 |  |
| Day cab vehicles | N1 |  |
| | N2 |  |
| | N3 |  |
| | N3 |  |

# ANNEX C - ASSESSMENT OF THE PROTECTIVE LEVELS OF STRUCTURES

## C.1 Procedure

1. This Annex describes the procedure for completing the form at Appendix 1 for the assessment of the protective levels of structures, whether new or existing, ensuring that only the required trials are completed as well as assisting with efficient data collection and recording. This means that not all threat categories need to be tested for all structures, depending on the role, location, and assessed threat.

2. It is essential to assess any potential and usually unintended adverse effects caused by structures on the functioning of weapons, for example early/air-burst detonation that might be caused by tents or light sun-screens.

## C.2 New structures

3. The process that should be followed to assess the protective levels required of new structures, to inform the design, is as follows:

| Step | Activity | Remarks |
|---|---|---|
| **Step 1 - Threat** | Identify the threats (weapon categories) to which the facility is likely to be subjected. Even if it is not intended to protect against some of the larger/less likely weapons, the potential effect/ mode of functioning of such systems should be assessed to ensure that the design adopted does not magnify the effect unintentionally. | |
| **Step 2 - Protection Requirement** | Establish the required levels of protection; complete Appendix 1 (assessment of the protective levels of structures) to support the description of the requirement (User Requirement Document); it must state clearly the threats against which the structure should provide protection. | |
| **Step 3 - Design and analysis** | As the design of a structure is developed and certainly once the design has been agreed, it should be analysed to establish the likely failure modes and the weapons likely to have the greatest impact. | Repeat as necessary (Steps 3 to 5) |
| **Step 4 - Assurance** | The required levels of assurance should be established (see Annex B) and, where practicable, the design should be subjected to trials; the analysis/results should be added to Appendix 1. | |
| **Step 5 - Additional Mitigation** | If additional mitigation measures (eg, stand-off, detonation screens) is required to achieve the levels of protection required (established in steps 1 and 2), this should be designed, analysed and trialled (where practicable). Appendix 1 should be amended in light of any additional mitigation measures. | |

## C.3 Existing or hybrid structures

4. Once a decision has been taken to occupy an existing structure on more than just a very temporary basis the protection it might provide should be assessed. Initially this would be a hasty assessment completed by the occupying troops, who may not be engineers, but it should be done by a combat engineer if possible (unless a technically qualified engineer is available). Subsequently a deliberate assessment should be completed by a technically qualified engineer to confirm the initial hasty assessment or to identify any risk mitigation that might be required. The process that should be followed to assess the protective levels of existing structures is as follows:

| Step | Activity | Remarks |
|---|---|---|
| **Step 1 - Threat** | Indentify the threats (weapon categories) to which the facility is likely to be subjected. | |
| **Step 2 – Analysis of structure** | Analyse the structure and complete Appendix 1 to determine whether it will provide protection against the threats identified in step 1. The analysis should incorporate information/data from assessments/trials of similar structures/design standards. Subsequently, if time allows, a full analysis should be completed to assess the maximum protection that the structure could provide in case the threat escalates. In addition, the potential effect/ mode of functioning of some of the larger/less likely weapons should be assessed to ensure that the form of the structure does not magnify the effect unintentionally. | Repeat as necessary |
| **Step 3 - Assurance** | The required levels of assurance should be established (see Annex B) and, where practicable, the structure should be subjected to trials; the analysis/results should be added to Appendix 1. If this is not possible, then testing a similar structure or component may be a useful alternative. | |
| **Step 4 - Additional Mitigation** | If the structure cannot protect against the threats identified in step 1 and the level of risk is unacceptable, there may be a requirement for additional mitigation measures (eg, stand-off, detonation screens). This should be designed, analysed and trialled (where practicable); Appendix 1 should be amended in light of any additional mitigation measures. | |

## C.4 Recording information

5. When recording information about trials or live events on operational infrastructure it is essential that comprehensive information about the target/weapon, as well as any other details of the circumstances, is included. This will allow trials to be repeated, similar conditions to be used in other trials, results to be reinterpreted by third parties and assessments of real structures to be understood when, for example, bases are transferred between nations.

6. Should field trials be possible/ necessary, they should be conducted in accordance with Annex B as far as practicable.

7. When recording the assessed protection level against each weapon category the following grading system should be used:

a. Pass: P- complies with all required standards;

b. Conditional: C - complies with most of the required standards;

c. Fail: F - does not comply with the required standards;

d. Pass (Assumed) – P(A) - not tested, but the structure or similar structure has withstood the effects of threats (passed) that are deemed greater.

e. Not tested – NT - not tested and suitable evidence to support a conclusion is not available.

8. The form at Appendix 1 has been designed to assist with recording information about the protection provided by structures against weapons. In order to fit the form on a single page the space allowed for the information has been minimised and font size 8 has been used. For practical use, the form should be reproduced locally allowing more space for the information and increasing the font size if desired.

9. Judgement will need to be used when completing the form but, in general, it will be better to provide more background information from the outset than to find subsequently that there is insufficient detail. Some or all of the following information should be included:

a. The completed form should include as much detail as possible about the structure/facility to enable effective operation, maintenance, improvement and transfer between units/nations. This should include such details as the type of structure, construction materials, dimensions, etc.

b. Additional pages should be added as necessary to give a complete history and full picture of the structure/facility. This could include a map showing the location, plans with the detailed layout, photographs, engineering drawings, sketches, etc.

c. Specific structures or weapon events should be identified on plans, for example with a letter, or a grid could be laid over the plan to assist with locating specific points. These labels should then be used when completing the form.

d. A chronology and description of completed works, including details of 'add-on' improvements to Force Protection, for example the retro-building of blast walls between accommodation units, should be included.

e. Suggested additional improvements that might be required.

f. Key information; including, for example, whether the structure passes, passes conditionally or fails and whether any additional risks have been identified.

g. The chart at top right of the form should be completed using the pass/fail grading in paragraph 7 of the Annex; in addition, for ease of reference, the details could be colour coded [Pass – green, Conditional pass – yellow, Fail – red]

h. Additional lines/space may be added as required.

i. Any assumptions, constraints or significant factors, for example whether or not the weakest part of the structure was directly targeted in trials, should be noted.

j. If a structure passes in one mode yet fails another, such as preventing penetration from a direct hit of a 155mm shell but allowing lethal blast to enter, a conditional pass shall be recorded.

10. A worked example of the form for the assessment of the protective levels of structures is at Appendix 2.

List of Appendices:

1. Form for the assessment of the protective levels of structures.

2. Worked example of the form for the assessment of the protective levels of structures.

### FORM FOR THE ASSESSMENT OF THE PROTECTIVE LEVELS OF STRUCTURES

[ONCE COMPLETED, A NATIONAL SECURITY CAVEAT MAY BE INSERTED IF REQUIRED]

| Base ID | ASSET ID | Date Built | Location | NSN | Use | Pers |
|---|---|---|---|---|---|---|
| | | | | | | |

**Key information**

**Structure/installation details**

| Category | | A | B | C | D | E |
|---|---|---|---|---|---|---|
| Severity of effect (level) | 9 | | | | | |
| | 8 | | | | | |
| | 7 | | | | | |
| | 6 | | | | | |
| | 5 | | | | | |
| | 4 | | | | | |
| | 3 | | | | | |
| | 2 | | | | | |
| | 1 | | | | | |

| CLASS | | Comments / references: | Secondary Effects | Method | Grade (P/C/F) |
|---|---|---|---|---|---|
| A: Projectiles | 9 | | | | |
| | 8 | | | | |
| | 7 | | | | |
| | 6 | | | | |
| | 5 | | | | |
| | 4 | | | | |
| | 3 | | | | |
| | 2 | | | | |
| | 1 | | | | |

| B: Direct fire | | Comments / references: | Secondary Effects | Method | Grade (P/C/F) |
|---|---|---|---|---|---|
| | Fragmentation | | | | |
| | Dynamic Penetration | | | | |
| | Shaped Charge | | | | |
| | Blast | See Section D | | | |

| C: Indirect fire | | Comments / references: | Secondary Effects | Method | Grade (P/C/F) |
|---|---|---|---|---|---|
| | Fragmentation | | | | |
| | Dynamic Penetration | | | | |
| | Blast | See Section D | | | |

| D: High explosives (TNT equivalent) | | | Structural Failure | | Personnel Vulnerability | | |
|---|---|---|---|---|---|---|---|
| | | Comments / Method: | Max Breach Range (m) | Secondary Effects | Higher Threshold Range (m) | Lower Threshold Range (m) | Reduction in Effect (%) |
| | 9 | | | | | | |
| | 8 | | | | | | |
| | 7 | | | | | | |
| | 6 | | | | | | |
| | 5 | | | | | | |
| | 4 | | | | | | |
| | 3 | | | | | | |
| | 2 | | | | | | |
| | 1 | | | | | | |

| E: Moving vehicles | | Comments / references: | Method | Grade (P/C/F) |
|---|---|---|---|---|
| | 6 | | | |
| | 5 | | | |
| | 4 | | | |
| | 3 | | | |
| | 2 | | | |
| | 1 | | | |

| Date / Place | | OUTGOING UNIT | | NAME / RANK | |
|---|---|---|---|---|---|
| APPROVED BY | | INCOMING UNIT | | NAME / RANK | |
| COMMENTS ON RECEIPT | | | | | |

Notes:

1. The completed form should include as much detail as possible about the structure/facility to enable effective operation, maintenance, improvement and transfer between units/nations. This should include such details as the type of structure, construction materials, dimensions, etc.

2. Additional pages should be added as necessary to give a complete history and full picture of the structure/facility. This could include a map showing the location, plans with the detailed layout, photographs, engineering drawings, sketches, etc.

3. Specific structures or weapon events should be identified on plans, for example with a letter, or a grid could be laid over the plan to assist with locating specific points. These labels should then be used when completing the form.

4. A chronology and description of completed works, including details of 'add-on' improvements to Force Protection, for example the retro-building of blast walls between accommodation units, should be included.

5. Suggested additional improvements that might be required.

6. Key information; including, for example, whether the structure passes, passes conditionally or fails and whether any additional risks have been identified.

7. The chart at top right of the form should be completed using the pass/fail grading in paragraph 7 of the Annex; in addition, for ease of reference, the details could be colour coded [Pass – green, Conditional pass – yellow, Fail – red].

8. Additional lines/space may be added as required.

9. Any assumptions, constraints or significant factors, for example whether or not the weakest part of the structure was directly targeted in trials, should be noted.

10. If a structure passes in one mode yet fails another, such as preventing penetration from a direct hit of a 155mm shell but allowing lethal blast to enter, a conditional pass shall be recorded.

**WORKED EXAMPLE - ASSESSMENT OF THE PROTECTIVE LEVELS OF STRUCTURES**

[ONCE COMPLETED, A NATIONAL SECURITY CAVEAT MAY BE INSERTED IF REQUIRED]

| Base ID | ASSET ID | Date Built | Location | NSN | Use | Pers |
|---|---|---|---|---|---|---|
| VIKING | VK 101 BG HQ | May 11 | 8 Fig grid | N/A | Company HQ | 25 |

**Key information**

Threats in order of likelihood: 107 (pri 1), RPG (Variant Pri 2), VBIED 250Kg (Estimate) closest proximity 75m standoff, 7.62mm AP sniper

Perimeter Mil 2:1 HESCO Wall

References in table to key Weapon events:

**Structure/installation details** (Ref attached site sketch and summary)

RC frame double storey (unspecified reinforcement detailing): max bay 3.0m

Masonry infill panels: Single clay brick 400 mm thick

Min distance from perimeter 30m:

Perimeter construction 2:1 Mil 1 HESCO - well compacted fill

Roof construction not determined: assumed 300 mm thick unreinforced slab

| Category | | A | B | C | D | E |
|---|---|---|---|---|---|---|
| Severity of effect (level) | 9 | F | F | F | 0% | F |
| | 8 | F | F | F | 0% | F |
| | 7 | F | F | F | 0% | F |
| | 6 | F | F | F | 40% | F |
| | 5 | F | F | F | 50% | F |
| | 4 | F | F | C | 70% | F |
| | 3 | P | C | P | 80% | C |
| | 2 | P | P | P | 100% | P |
| | 1 | P | | P | 100% | P |

| CLASS | | Comments / references: | Secondary Effects | Method | Grade (P/C/F) |
|---|---|---|---|---|---|
| A: Projectiles | 9 | | | | F |
| | 8 | | | | F |
| | 7 | | | | F |
| | 6 | | | | F |
| | 5 | | | | F |
| | 4 | Field trials of 0.5 at 300 m range of like structure | | Trials | F |
| | 3 | ***A***. Historic effects observed on Masonry Panel. | | Observation | P |
| | 2 | | | | P |
| | 1 | | | | P |

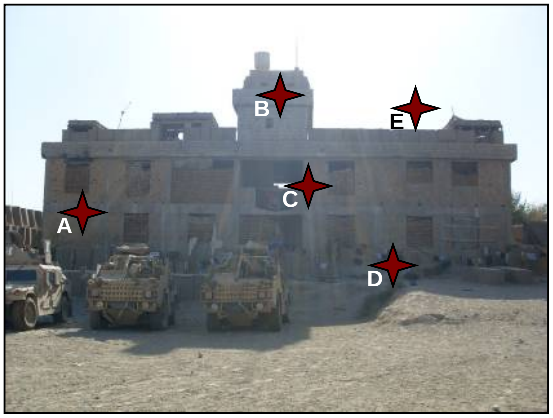
| B: Direct fire | | Comments / references: | Secondary Effects | Method | Grade (P/C/F) |
|---|---|---|---|---|---|
| | Fragmentation | ***B***. Nil frag pen adjacent structures | Nil | Observation | C |
| | Dynamic Penetration | ***B***. Assessed that wpn functioned on surface and rocket motor penetrated to impact on rear wall | Moderate spalling from rear face | Observation | C |
| | Shaped Charge | ***B***. ***C:*** RPG 7. Nil pen of RC frame | Spalling masonry panels and frame | Observation | F |
| | Blast | See Section D | | | |

| C: Indirect fire | | Comments / references: | Secondary Effects | Method | Grade (P/C/F) |
|---|---|---|---|---|---|
| | Fragmentation | ***B, D, E*** , apertures in structure not protected against frag pen | Surface damage to Sandbag walls | Observation | C |
| | Dynamic Penetration | ***E***. Max pen of roof 100mm | Minor concrete frag. | Observation | P |
| | Blast | See Section D | | | |

| D: High explosives (TNT equivalent) | | Structural Failure | | | Personnel Vulnerability | | |
|---|---|---|---|---|---|---|---|
| | | Comments / Method: | Max Breach Range | Secondary Effects | Higher Threshold Range (m) | Lower Threshold Range (m) | Reduction in Effect (%) |
| | 9 | Analysis | | Structural Collapse | | | F |
| | 8 | Analysis | | Structural Collapse | | | F |
| | 7 | ***G***. Observation post attack | | Damage to HESCO wall and Sandbag infills | 14.5 | 36.0 | C |
| | 6 | ***G***. Observation post attack | | | 8.3 | 21.0 | C |
| | 5 | | | | 4.4 | 12.3 | C |
| | 4 | ***D,E,F*** Observation against Masonry Panels only | | | | | P |
| | 3 | | | | | | P |
| | 2 | | | | | | P |
| | 1 | | | | | | P |

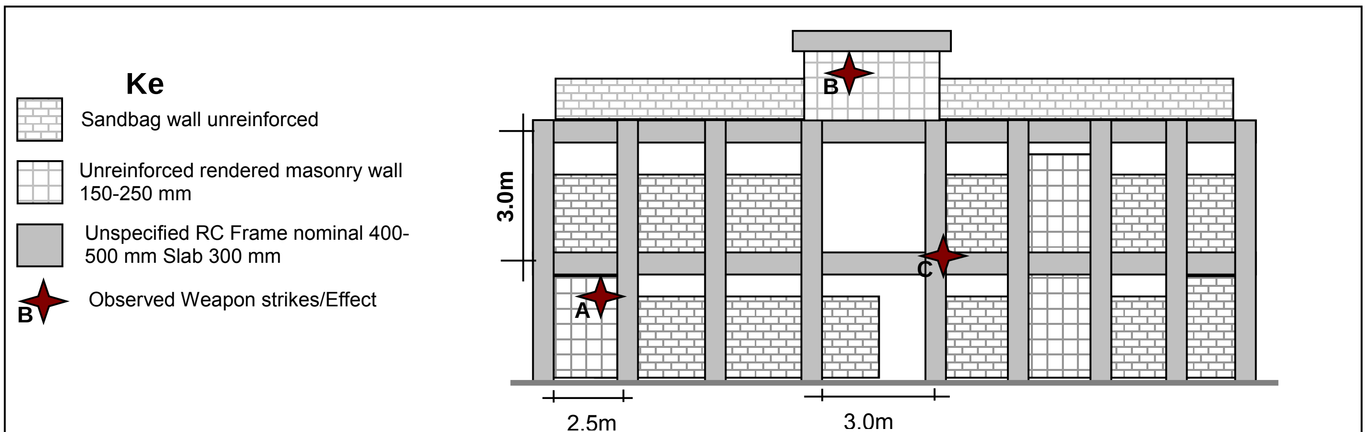
| E: Moving vehicles | | Comments / references: | Method | Grade (P/C/F) |
|---|---|---|---|---|
| | 6 | Assume worst case in terms of structural redundancy therefore disproportional collapsed expected. Additional Vehicle mitigation measures in place to prevent vehicle penetration of North East wall. Assessed as most likely risk following complex attack. | Structural Frame Analysis | F |
| | 5 | | | F |
| | 4 | | | F |
| | 3 | | | F |
| | 2 | | | P |
| | 1 | | | P |

| Date / Place | 1/2/14 | OUTGOING UNIT | 22 ER | NAME / RANK | E Heckler Maj |
|---|---|---|---|---|---|
| APPROVED BY | RJM | INCOMING UNIT | 1 D ER | NAME / RANK | T Koch Maj |
| COMMENTS ON RECEIPT | Initial inspection carried out by Level 2 FPE followed by structural assessment by Level 3 CEng. Adverse weather during the winter has degraded the condition of the roof structure and will require a structural reassessment within the next 2 months. | | | | |

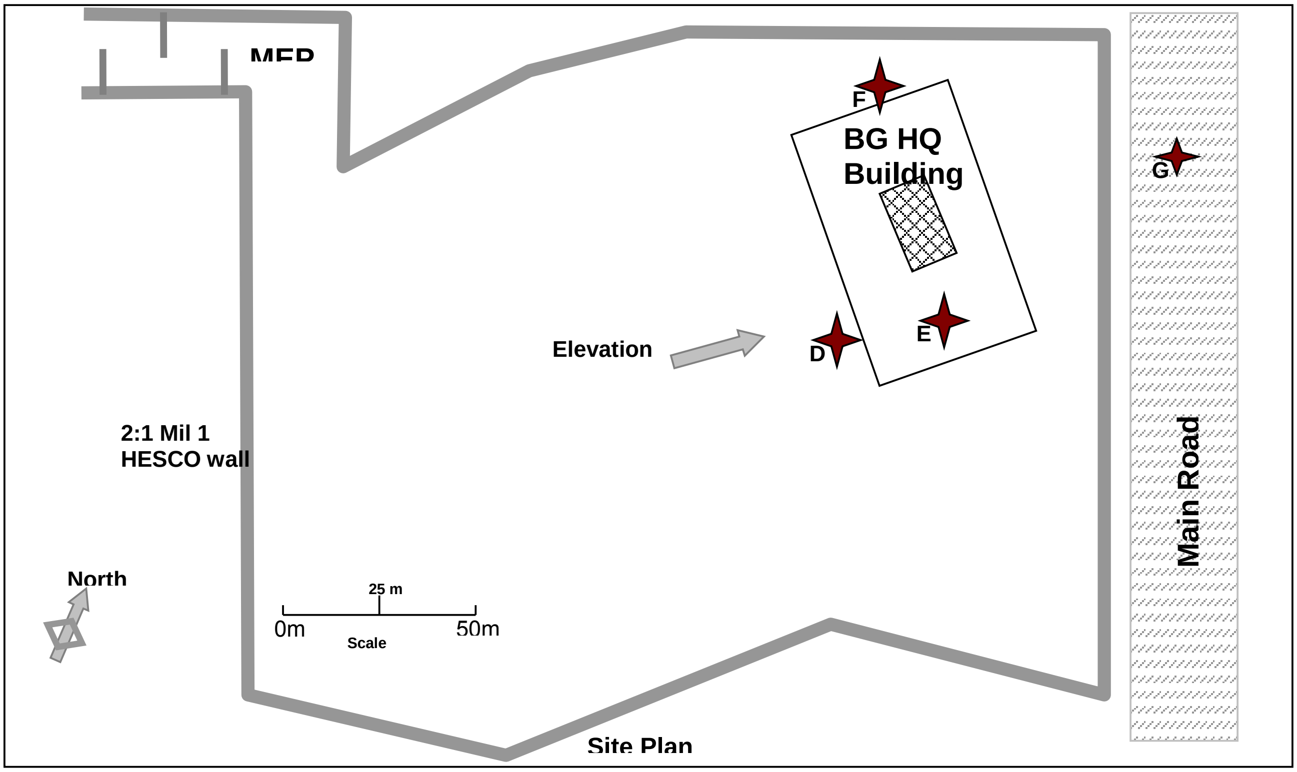



**Summary of weapon events**

**A.** 7.62mm, 5-15 rds unconfirmed date, nil penetration.
**B.** RPG, Jul 13, penetration, nil fragmentation penetration.
**C.** RPG, Sep 13, Surface denotation on frame, minor surface scabbing, no structural penetration.
**D.** 107mm, Sep 13, Impact 7m from elevation, nil structural damage surface damage of ground floor sandbag face.
**E.** 107mm, Oct 13, 100 mm penetration of roof slab, no underside damage.
**F.** 107mm, Oct 13, in contact with masonry wall, some internal surface scabbing.
**G.** VBIED, Oct 13, estimate 150-200kg (TNT eqv), 2 bays of Masonry panel damaged (Groundfloor) and 1 panel sandbag destroyed Groundfloor .



**South West Elevation**




**(ONCE COMPLETED, A NATIONAL SECURITY CAVEAT MAY BE INSERTED IF REQUIRED)**

INTENTIONALLY BLANK

# ANNEX D – LEXICON

## Part I – ACRONYMS AND ABBREVIATIONS

### Abbreviations - General

| | |
|---|---|
| AJP | Allied Joint Publication |
| CBR | California Bearing Ratio |
| CBRN | Chemical, Biological, Radiological and Nuclear |
| IED | Improvised Explosive Device |
| JDP | Joint Doctrine Publication |
| NATO | North Atlantic Treaty Organisation |
| PAS | Publically Available Standard |
| R&D | Research and Development |
| STANAG | Standardisation Agreement |
| UFC | Unified Field Code |
| VBIED | Vehicle Borne Improvised Explosive Device |

### Abbreviations – Weapons Related

| | |
|---|---|
| AP | Armour Piercing |
| AP WC | Armour Piercing Wad Cutter |
| APDS | Armour Piercing Discarding Sabot |
| API | Armour Piercing Incendiary |
| ASM | Anti Structure Munition |
| COMP B | Composition B |
| HE | High Explosive |
| HEAT | High Explosive Anti-Tank |
| HEDP | High Explosive Dual-Purpose |
| HMG | Heavy Machine Gun |
| MBT | Main Battle Tank |
| PDW | Personal Defence Weapon |
| RPG | Rocket Propelled Grenade |
| SMG | Sub Machine Gun |
| TNT | Trinitrotoluene |

## Part II – TERMS AND DEFINITIONS

1. The following definitions have been taken from Reference I, AAP-6:

   a. Field Fortification. An emplacement or shelter of a temporary nature which can be constructed with reasonable facility by units requiring no more than minor engineer supervisory and equipment participation.

   b. Shaped Charge. A charge shaped so as to concentrate its explosive force in a particular direction.

2. The following terms are introduced for use in this document alone.

   a. Blast Ingress. The overpressure that enters into a structure from an external detonation.

   b. Deployed Infrastructure. Any capability that is used in a theatre of operations to provide passive protection to personnel or equipment from the weaponry of belligerent forces.

   c. Deployable Protective Structure. Complete structure acquired prior to deployment, which is placed or assembled on sire without the use of additional protective materials.

   d. Dynamic Penetration. A measure of the depth of penetration of duds, bullets, fragments, and the inert components of rockets and mortars such as motors and tail fins.

   e. Field Tested. A test carried out in the field with standard weaponry, without the use of advanced diagnostic equipment. Guidelines for such tests are given in Annex C of this standard.

   f. Force Protection Equipment. Any material used to enhance security, but not for defeating or neutralizing weapons effects, e.g. vehicle barriers.

   g. Fragmentation. The small, fast-moving, irregularly shaped pieces created from warhead components or charge casing upon detonation.

   h. Passive Protection. The physical protection provided by a structure against a weapon that impacts and functions as designed.

   i. Perforation. Projectile must pass completely through the target[7].

   j. Projectile Penetration. The distance the tip of a projectile as travelled into a target/material[8].

[7] Paraphrased from British Army; Military Engineering Volume 9, Part 1 Force Protection Engineering

k. Residual Risk. Any known shortcomings, including intentional design limitations, of the protective capability of a structure against a design threat. Residual risk may be associated with less protected parts of structure, or certain weapons or impact situations not accounted for (e.g. direct hit or certain impact angles). Residual risk may be described in a qualitative manner.

l. Severity. In accordance with Annex A, the escalating scale of effect from 1-5, by weapon category.

m. Tested. An instrumented test carried out in a controlled environment in accordance with good scientific practice.

n. Vehicle Penetration. In the case of vehicles, penetration is the maximum distance that the forward edge of the load platform (or passenger compartment in a car) moves beyond the initial forward edge of the barrier[9].

[8] Australian Army; Land Warfare Procedures – Combat Arms (Engineers) 4-3-2, Blast and Ballistic Effects.

[9] Reference G: PAS 68 (2010)

## *REFERENCES PUBLICATIONS AND RELATED DOCUMENTS*

A. (NATO) JDP 3.64 Force Protection

B. (UK) Military Engineering Volume 9 Part I, Force Protection Engineering

C. (UK) Military Engineering Volume 9 Part II, Force Protection Engineering

D. (US) UFC 3-340-02, Design and analysis of hardened structures to conventional weapons effects

E. (US) UFC 4-022-02, Security fences and gates.

F. (NATO) STANAG 4569, Protection levels for occupants of armoured vehicles.

G. (UK) PAS 68 Impact Test Specification for Vehicle Security Barriers

H. AJP-3.14 – Allied Joint Doctrine for Force Protection

I. AAP-6 – NATO Glossary of Terms and Definitions

J. AJP-3.12 - Allied Joint Doctrine for Military Engineering

K. ATP-52(B) (being rewritten as ATP-3.12.1) - Allied Tactical Doctrine for Military Engineering

L. ACO Directive (AD) 80-25 (ACO Force Protection - NR).

# ATP-3.12.1.8 (A)(1)