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Vehicle security barriers —

Part 1: Performance requirement, vehicle impact test method and performance rating

Barrières de sécurité de véhicule —

Partie 1: Exigence de performance, méthode d'essai d'impact du véhicule et taux de performance

Reference number
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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

International Workshop Agreement IWA 14 was sponsored by UK Government's Centre for the Protection of National Infrastructure (CPNI) on behalf of the international community. The development of this IWA was facilitated by BSI Standards Limited. It came into effect on 15 November 2013.

IWA 14 consists of the following parts, under the general title *Vehicle security barriers*:

— *Part 1: Performance requirement, vehicle impact test method and performance rating*

— *Part 2: Application*

This corrected version of IWA 14-1:2013 incorporates editorial modifications.

Introduction

0.1 Workshop contributors

Acknowledgement is given to the following organizations that were involved in the development of this International Workshop Agreement:

— Allen Total Perimeter Security Limited

— APT Security Systems

— ATG Access Ltd

— BRE Global Limited

— Bristorm, Hill and Smith Ltd

— Centre for the Protection of National Infrastructure (CPNI)

— DELTA BLOC International GmbH

— GME Springs/Safetyflex Barriers

— Heald Limited

— HMS Nelson, Portsmouth Naval base

— Kirchdorfer Fertigteilholding GmbH

— L.I.E.R.

— Marshalls

— MFD International Limited

— Ministry of Commerce and Industry - Director General for Standards and Metrology (DGSM) (Sultanate of Oman)

— MIRA Ltd

— Norwegian Defence Estates Agency

— Perimeter Protection Group

— Perimeter Security Suppliers Association

— Rhino Engineering Ltd

— Royal Military Academy - Civil and Materials Engineering Department

— RSSI Barriers

— Sälzer GmbH

— Scorpion Arresting Systems LTD

— Ministry of Home Affairs (Singapore)

— Sudanese Standard and Metrology Organization (SSMO)

— Syrian Arab Organization for Standardization and Metrology (SASMO)

— Tallwang KVI PTY Ltd t/a AVS-elli

— Technical and Test Institute for Construction Prague

— Texas A&M Transportation Institute

— Transport Research Laboratory (TRL)

— US. Department of State

— US. Nuclear Regulatory Commission

— US. Army Corps of Engineers - Protective Design Center

0.2 Relationship with other publications

The following documents have been used to inform the development of this International Workshop Agreement:

— ASTM F 2656

— CWA 16221

— PAS 68

— PAS 69

0.3 Information about this document

Product testing

Users of this part of IWA 14 are advised to consider the desirability of third-party testing of product conformity with this IWA. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI or any National Standards Body to forward their enquiries to the relevant association.

Vehicle security barriers —

Part 1:
Performance requirement, vehicle impact test method and performance rating

1 Scope

This part of IWA 14 specifies the essential impact performance requirement for a vehicle security barrier (VSB) and a test method for rating its performance when subjected to a single impact by a test vehicle not driven by a human being.

It also includes the following optional assessments that can be carried out as part of the vehicle impact test method:

a) pedestrian intruder access;

b) occupant injury.

It does not cover the performance of a VSB or its control apparatus when subjected to:

— blast explosion;

— ballistic impact;

— manual attack, with the aid of tools (excluding vehicles); or

— electrical manipulation/attack of the access control system.

NOTE 1 For manual attack, a variety of test methods exist. For assessing intruder resistance of building components see Bibliography.

NOTE 2 The VSB is designed and tested on the basis of its application, including:

a) vehicle type, mass and speed of the assessed vehicle-borne threat;

b) its geographical application (e.g. climate conditions);

c) intended site conditions (e.g. rigid or non-rigid soil).

It does not cover guidance on design, the operational suitability of a VSB or other impact test methods.

NOTE 3 Guidance on the selection and specification of a VSB by type and operational suitability is covered in IWA 14–2.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM C39 / C39M 10, *Standard test method for compressive strength of cylindrical concrete specimens*

EN 12390-2, *Testing hardened concrete — Part 2: Making and curing specimens for strength tests*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 vehicle security barrier (VSB)

3.1.1
vehicle security barrier
VSB
barrier used to prevent potentially hostile vehicular access to a site, which depending on its type might include as part of its design a foundation and/or operating equipment

Note 1 to entry: Types of VSB and their application are discussed in IWA 14–2.

3.1.2
linear VSB
VSB of variable length with no physical break in profile

Note 1 to entry: Examples of linear VSBs include structural walls, bunds/berms and wire rope systems.

Note 2 to entry: A linear VSB can have a change in profile, e.g. height and/or width.

3.1.3
passive VSB
VSB that after installation and deployment is static

Note 1 to entry: Examples of passive VSBs include structural walls, passive bollards and planters.

3.1.4
active VSB
VSB that after installation can be operated either by personnel or powered equipment to change its position and/or deployed state

Note 1 to entry: Examples of active VSBs include manual rising arm barriers and retractable bollards.

3.2 foundation

Note 1 to entry Examples of installations in and on a variety of foundation configurations are illustrated in Figure 1.

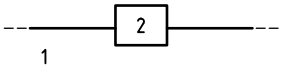
3.2.1
VSB foundation
foundation into which the VSB is installed and tested

3.2.2
generic VSB foundation
VSB foundation that can be used for testing a VSB (usually a passive bollard) which is not specifically designed with a proprietary foundation

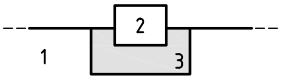
3.2.3
integral VSB foundation
VSB foundation that is a structural component of the VSB

3.2.4
proprietary VSB foundation
bespoke VSB foundation designed and sized solely for use with a specific VSB

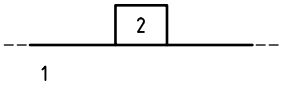
3.2.5
test site ground
surrounding land, in which the VSB foundation is situated or on which the VSB is installed for testing



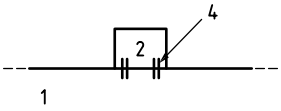
a) VSB in the test site ground



b) VSB in its foundation, installed into test site ground



c) VSB on test site ground (surface mounted)



d) VSB anchored/pinned/bolted to test site ground

Key

1	test site ground	3	VSB foundation
2	VSB	4	anchor/pin/bolt

NOTE VSBs have a variety of foundation configurations, e.g. a) and b), where others are installed directly on the ground, e.g. c) and d).

Figure 1 — Examples of installations in and on a variety of foundation configurations — Section view

3.3 vehicle

3.3.1
test vehicle
commercially available vehicle and load bed (for N1, N2 and N3 vehicles), the vehicle having an unmodified chassis and unmodified frontal structure, used in an impact test to evaluate the performance of a VSB

Note 1 to entry: Modifications that are permissible include the addition of a load bed (in accordance with the vehicle manufacturer's instructions) and methods to restrain movement of ballast.

3.3.2
A-pillar
structural member forming the forward corner of the driver compartment of a vehicle (M1, N1G and N1) or day cab (N2 and N3) of a vehicle

3.3.3
ballast
mass added to the test vehicle to bring the test vehicle mass within tolerance

Note 1 to entry: Table 1 specifies the permissible quantities of secured and unsecured ballast.

3.3.4
crew cab
four door compartment of N1G vehicle for driver and passengers

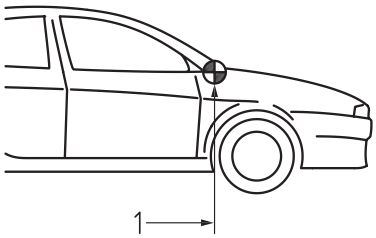
3.3.5
day cab
driver compartment of N1, N2 or N3 vehicle that does not include overnight facilities

3.3.6
unladen mass
mass of test vehicle, excluding ballast but with manufacturer's equipment, quantities of engine oil and coolant, and minimum amount of fuel

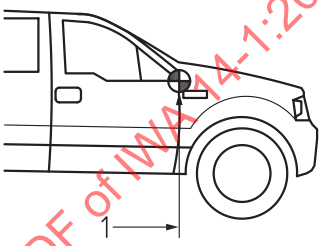
Note 1 to entry: A minimum amount of fuel is required to ensure engine operation during the test which in turn facilitates power steering and braking systems.

3.4 datum line

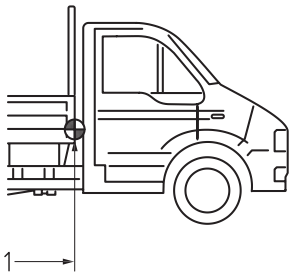
3.4.1
vehicle datum point
for car (M1) or 4x4 crew cab pick-up (N1G) vehicle [see Figure 2a) and Figure 2b)]:reference line passing through the centre of the A-pillars, at the lowest point of the windscreen; for N1, N2 or N3 day cab vehicles [see Figure 2c) and Figure 2d)]:reference line intersecting the load bed and the headboard



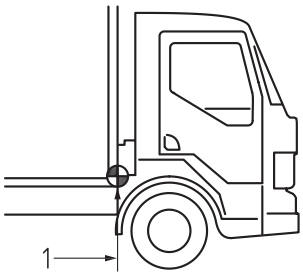
a) Car (M1)



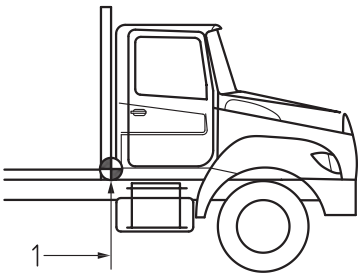
b) 4x4 crew cab pick-up (N1G)



c) Day cab vehicle (N1)



d) Day cab vehicle (N2A, N3C, N3D and N3F)



e) Day cab vehicle (N2B and N3E)

Key
1 vehicle datum point

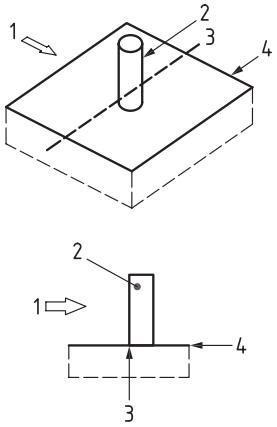
Figure 2 — Vehicle datum point — Side view

3.4.2
VSB datum line
vertical line taken pre-impact, from the ground to the furthest protrusion of the front face of the VSB structure designed to withstand the impact

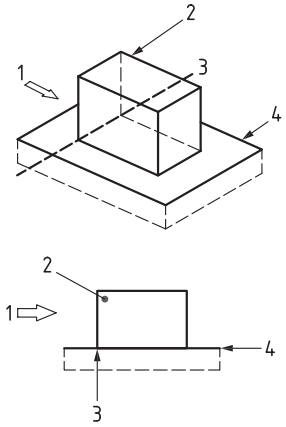
Note 1 to entry: The VSB front face could be flat and perpendicular to the ground. In this case, the whole VSB front face is in line with the VSB datum line. In the case of a blocker, it is the furthest protrusion of the VSB structure designed to withstand the impact [see Figure 3c)].

Note 2 to entry: The front face of the VSB is not the same as the front face of the VSB foundation or any supporting structure. In the case of a ditch, it is the point where the front face of the ditch meets the ground level.

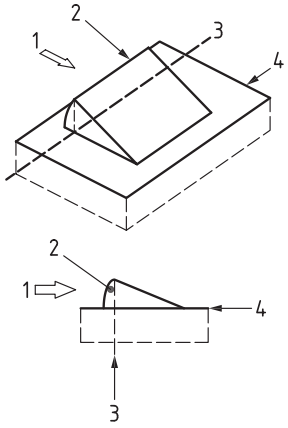
Note 3 to entry: The VSB datum line is illustrated in Figure 3.



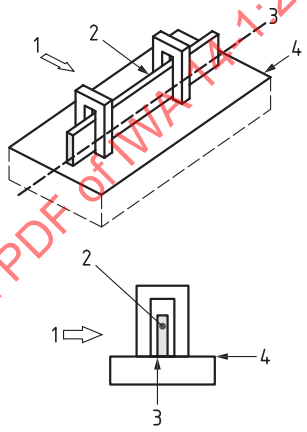
a) Bollard



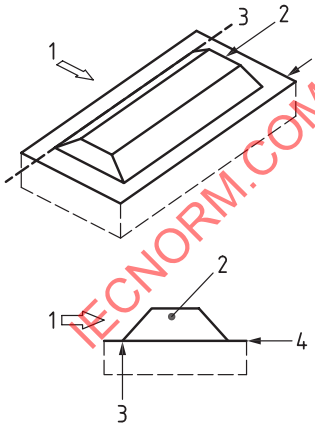
b) Planter, wall, balustrade



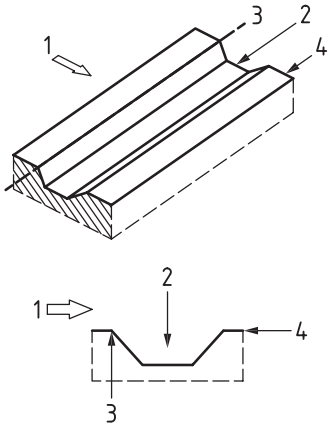
c) Blocker



d) Gate barrier, rising/swing arm barrier



e) Bund/berm



f) Ditch

Key

1	direction of impact	3	VSB datum line
2	VSB	4	ground level

NOTE 1 IWA 14-2 provides information on the different types of VSB available.

NOTE 2 For c), refer to Note 1 to 3.4.2

Figure 3 — VSB datum line — Isometric and side view

3.5 impact

3.5.1
impact speed
speed of the freely moving test vehicle before reaching the initial contact point

3.5.2
impact angle
angle >0° and ≤90° in the horizontal plane between the VSB datum line and the vehicle approach path into the VSB

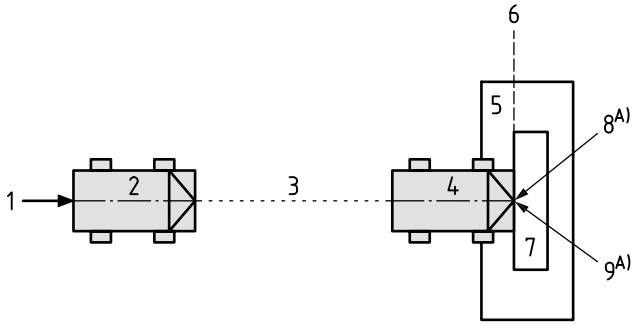
Note 1 to entry: The impact angle is illustrated for clarity in Figure 4.

3.5.3
target impact point
intersection between the longitudinal centre line of the test vehicle and the lateral position on the VSB impact face

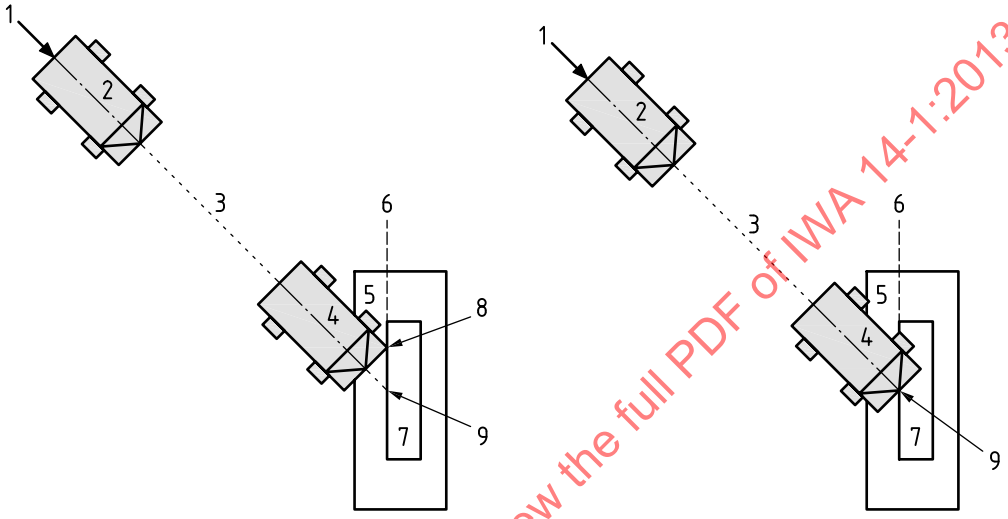
Note 1 to entry: The target impact point is illustrated for clarity in Figure 4 and is used to determine test vehicle to VSB alignment for impact angles > 45°. For an impact test with a 90° impact angle, the target impact point and the initial contact point are the same.

3.5.4
initial contact point
point at which the test vehicle and the VSB impact face first touch during the impact test

Note 1 to entry: The initial contact point is illustrated for clarity in Figure 4 and is used to determine test vehicle to VSB alignment for impact angles ≤ 45°.



a) Impact angle = 90°



b) Impact angle = 45°

Key

1	centre line of the test vehicle	6	VSB datum line (impact face)
2	test vehicle, pre-impact	7	VSB
3	vehicle approach path	8	initial contact point
4	test vehicle at impact	9	target impact point
5	VSB foundation	A)	For an impact test with a 90° impact angle, the target impact point and initial contact point are the same.

Figure 4 — Impact angle, target impact point and initial contact point — Aerial view

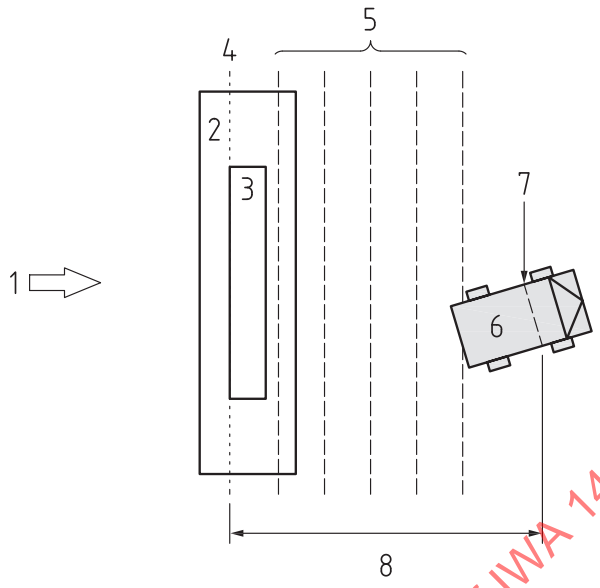
3.6 performance data

3.6.1
vehicle penetration distance

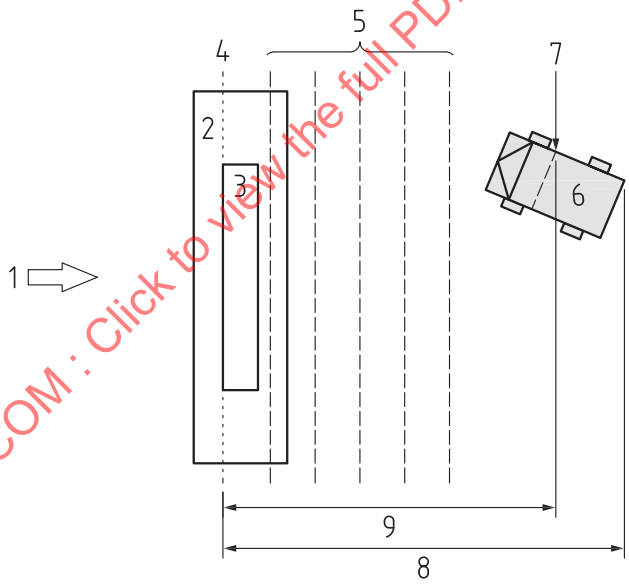
maximum perpendicular distance between the VSB datum line and either: a) where there is <90° yaw and/or pitch of the test vehicle, the vehicle datum point; or b) where there is ≥90° yaw and/or pitch of the test vehicle, the furthest part of the load bed (for N1, N2 and N3 vehicles) or furthest part of the vehicle (M1 and N1G vehicles), achieved either dynamically (during impact) or statically (post-impact), whichever is the greater

Note 1 to entry: Vehicle penetration distance is illustrated in Figure 5a) (aerial view) and Figure 6 (side views) with < 90° yaw and/or pitch of the test vehicle.

Note 2 to entry: Vehicle penetration distance is illustrated in Figure 5b) (aerial view) with ≥ 90° yaw and/or pitch of the test vehicle.



a) Impact at 90° to the VSB datum line, with <90° yaw and/or pitch of the test vehicle



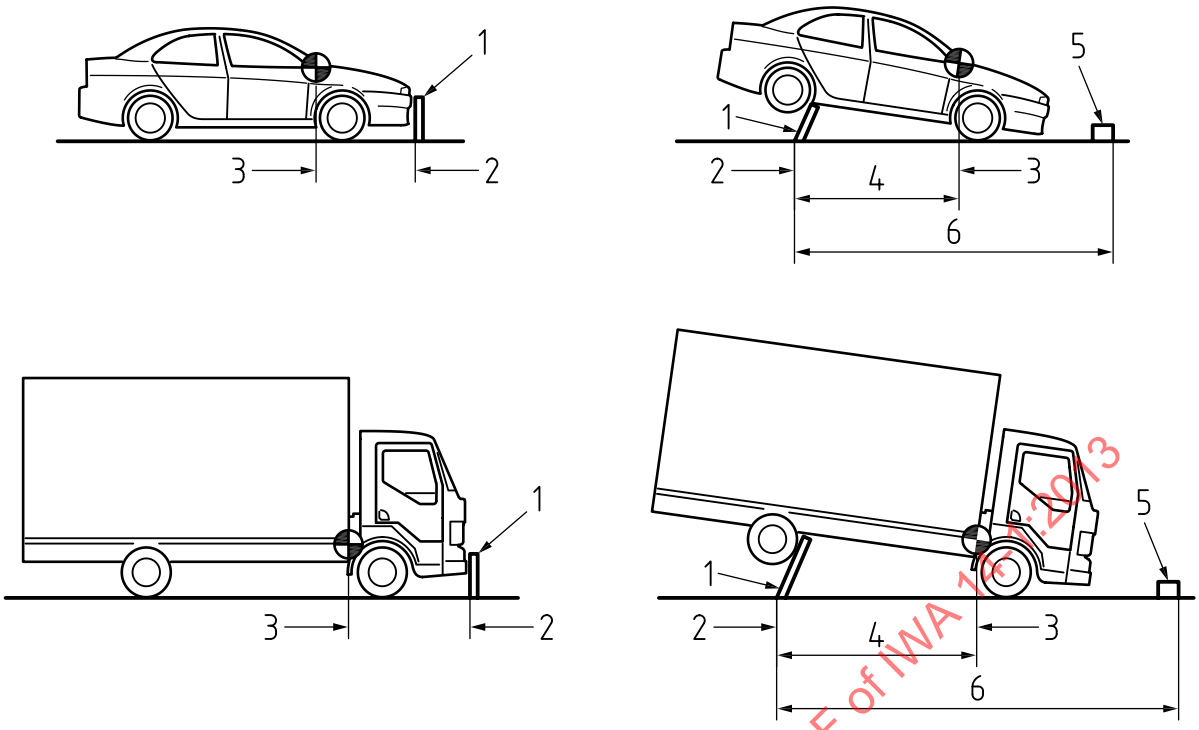
b) Impact at 90° to the VSB datum line, into a VSB with an angled impact face, with ≥90° yaw and/or pitch of the test vehicle (i.e. test vehicle facing towards the VSB post-impact)

Key

1	direction of impact	6	test vehicle, post-impact
2	VSB foundation	7	vehicle datum point
3	VSB	8	vehicle penetration distance
4	VSB datum line	9	VSB datum line to vehicle datum point (informative observation when vehicle has ≥ 90° yaw and/or pitch)
5	distance marks at ground level		

NOTE See Note 2 to 6.2.5.

Figure 5 — Vehicle penetration distance — Aerial view



a) Pre-impact **b) Post-impact**

Key

1	VSB (e.g. bollard)	4	vehicle penetration distance
2	VSB datum line	5	major debris
3	vehicle datum point	6	major debris distance

Figure 6 — Vehicle penetration distance and major debris distance – Side view

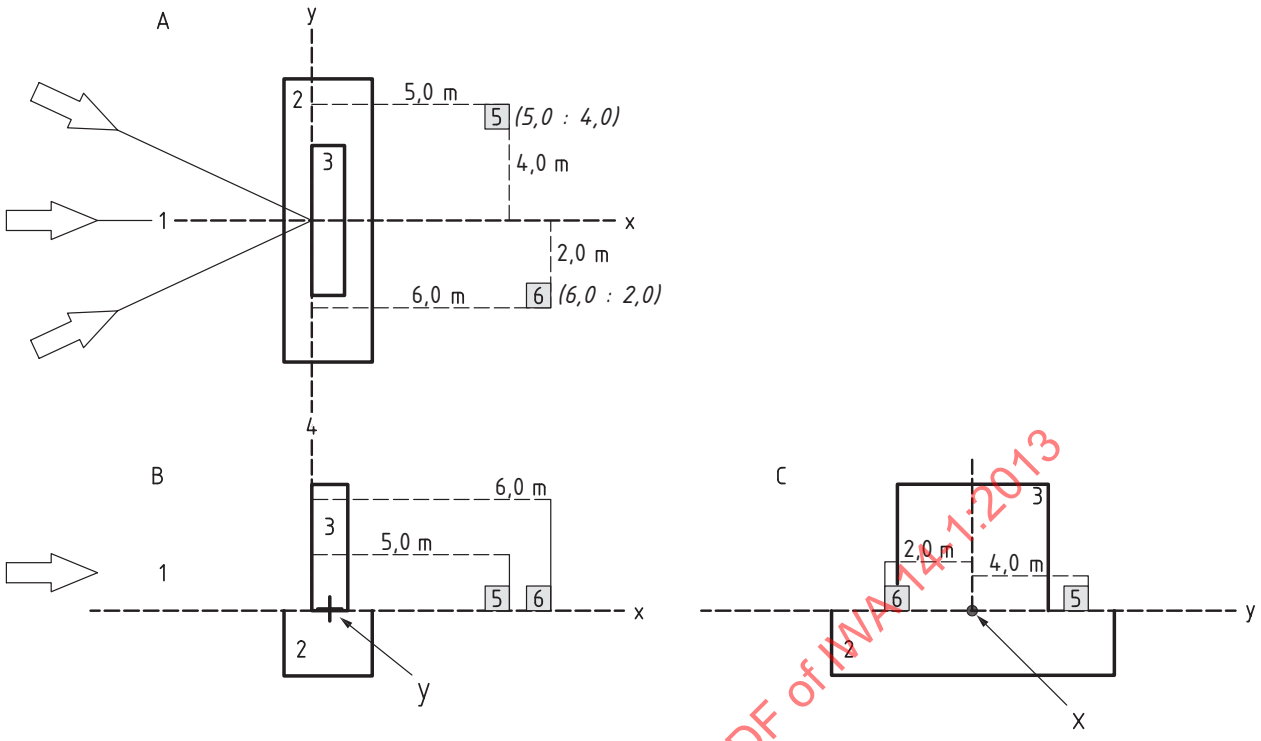
3.6.2
major debris
piece of VSB, vehicle or ballast with a mass of ≥25 kg that becomes totally detached during the vehicle-VSB impact

3.6.3
major debris distance
dimension measured from and perpendicular to the VSB datum line, to the furthest edge of the outermost piece of major debris

Note 1 to entry: Major debris distance is illustrated for clarity in Figure 6.

3.6.4
major debris co-ordinates
position of major debris measured in the x- and y-axes from either the target impact point where the impact angle is >45°, or from the initial contact point where the impact angle is ≤45°

Note 1 to entry: Major debris coordinates are illustrated for clarity in Figure 7.



Key

A	aerial view	2	VSB foundation
B	side view – y is going into page (symbol +)	3	VSB
C	end view – x is coming out of page (symbol •)	4	VSB datum line
1	direction of impact (three examples)	5, 6	major debris and its coordinates

Figure 7 — Major debris coordinates system — Aerial, side and end views

3.7 miscellaneous

3.7.1
client
person(s) or organization commissioning the test house to undertake an impact test

Note 1 to entry: The client could be the manufacturer, government agency, distributor, designer, prospective purchaser or installer of the VSB to be tested.

3.7.2
test house
person(s) or organization carrying out the vehicle impact test

4 Performance requirement

When tested in accordance with the test method in Clause 6, the VSB shall:

a) resist/restrain/deflect the test vehicle from advancing beyond the VSB; and/or

b) immobilize the test vehicle by trapping it; and/or

c) immobilize the test vehicle by preventing it progressing using its own engine power after the impact.

NOTE 1 If a test vehicle is immobilized, it is prevented from continuing on its course. This can be through the VSB blocking its route [see b)] or through damage to the test vehicle preventing it from operating [see c)].

NOTE 2 Test data recorded with respect to these requirements are used to form the performance rating (see Clause 7).

5 VSB documentation

5.1 General

The following information and documentation shall be requested before the vehicle impact test:

NOTE 1 This information sets the technical basis for the test activity.

a) VSB manufacturer details;

b) client details (where different to the VSB manufacturer);

c) whether the VSB is a prototype or is in production;

d) VSB product name (type and model);

e) the test parameters against which the VSB is to be tested, including:

   1) test vehicle (see 6.1.1);

   2) target impact point and impact angle (see 6.3);

   3) impact speed (see 6.6);

f) whether the following optional assessments are to be included in the test:

   1) pedestrian intruder access;

   2) occupant injury;

g) which face of the VSB is the front face (i.e. the face designed to resist impact) and how this is marked on the VSB;

h) general arrangement and detailed drawings, installation drawings and installation instructions;

   NOTE 2 Drawings should state they are to be used for the installation of the VSB being tested and be labelled with the VSB product name (type and model) [see 5.1d)] and version number that is being tested.

i) parts list (if available);

j) certificates confirming material specifications;

k) foundation specification:

   1) foundation type: none, generic, proprietary, integral;

   2) reinforcement detail and bar bending schedule;

   3) soil grade, compaction, moisture content and bearing capacity (where soil is part of the foundation or installation) (see 6.4.4);

l) operating manual/instructions;

m) for bollards, the bollard array and its foundation (e.g. single or multiple arrangement);

   NOTE 3 This includes, for example, use of a foundation with a capacity of three bollards but to be tested with only one bollard installed.

n) for linear VSBs, the length of the VSB to be tested;

NOTE 4 From experience, the length of a linear VSB chosen for impact testing should be considered as the performance could depend on it.

o) whether the VSB is a passive or active VSB and whether it is to be tested as passive or active;

p) for an active VSB, the means by which it is to be operated for the test (e.g. powered or manual);

q) whether the VSB has been previously tested including a reference to the previous test (e.g. test house, test reference number, test report number).

NOTE 5 The test house may obtain other relevant information (e.g. information for disposal and/or recycling of the VSB, details of toxic or dangerous materials in the VSB and safety issues).

All documents supplied to a test house shall be considered proprietary and shall be retained, handled and stored by the test house accordingly, unless instructed otherwise by the client.

5.2 Conformity between VSB and documentation

The VSB shall conform to its accompanying documentation (see 5.1). Any non-conformance identified at any stage of testing shall be logged and reported to the client. The resolution of the non-conformance shall be recorded through the provision of revised drawings prior to completion of the test report or a modified VSB prior to continuation of the test programme.

A set of modified drawings identified by an updated issue number shall be provided together with a list of dated amendments.

6 Test method

NOTE Documented procedures for ensuring the safety of observers during testing should be developed based on a site specific risk assessment for the test site and should be implemented.

6.1 Apparatus

6.1.1 Test vehicle, a production model representative of the current vehicle fleet, having characteristics and dimensions within the vehicle specifications given in Table 1.

NOTE 1 The test vehicle should be selected on the basis of the VSB's application, including its geographical application, where known.

NOTE 2 If using a vehicle with a rigid box, consideration should be given to how ballast movement could be filmed during the impact [see 6.1.8c)].

NOTE 3 Graphical representations of typical vehicles corresponding to requirements are given in Figure 8.

The test vehicle shall be not more than 10 years old for vehicle types M1, N1G, N1, N2A, N2B, N3C and N3D, and not more than 15 years for vehicle type N3E and N3F.

NOTE 4 For transparency of impartiality, the test house should always supply the test vehicle to ensure it meets the requirements of this IWA.

The test vehicle shall meet the requirements for road worthiness for the following:

a) tyres and wheels;

b) suspension;

c) wheel alignment;

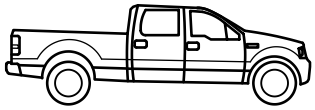
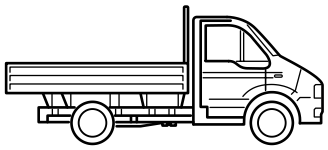
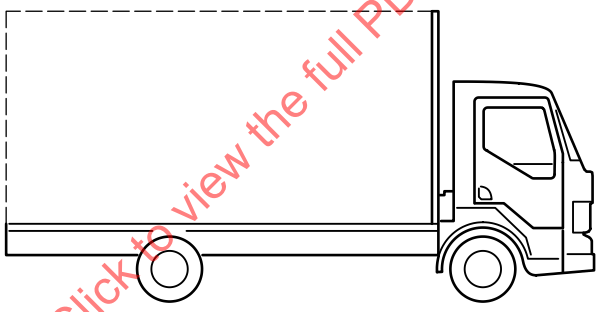
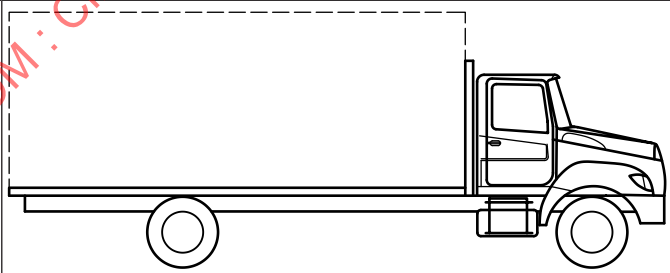
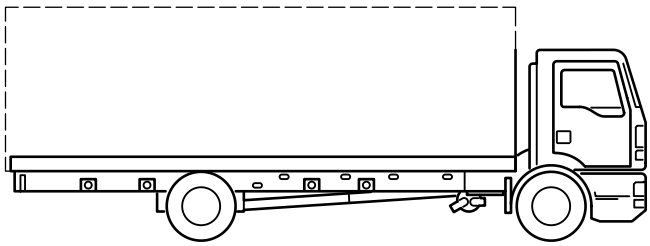
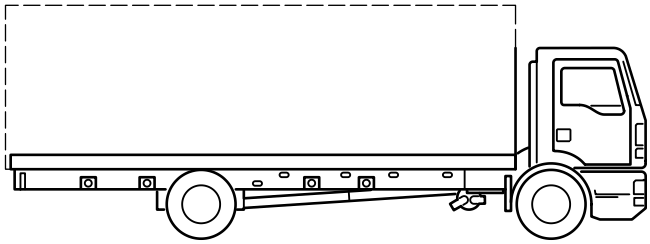
d) bodywork;

e) brakes;

f) chassis; and

g) engine, where the means of delivering the test vehicle to the VSB is by vehicle self power.

NOTE 5 The engine may need to be running to aid test preparation. Electronic sensors might also need to be deactivated to avoid altering the test vehicle's behaviour, for example, a safety braking system triggering due to the absence of a driver.

Type of test vehicle	**Vehicle classification and description**	**Test vehicle mass (kg)**	**Illustration**
Car	M1	**1 500**	
4x4 crew cab pick-up	N1G	**2 500**	
Flat bed	N1 *(single cab)*	**3 500**	
Day cab vehicle	N2A 7 500 kg 2-axle rigid *(flat bed, open curtain side or rigid box)*	**7 200**	
	N2B 12 000 kg 2-axle rigid *(flat bed, open curtain side or rigid box)*	**7 200**	
	N3C 18 000 kg 2-axle rigid *(flat bed, open curtain side or rigid box)*	**7 200**	
	N3D 15 000 kg 2-axle rigid *(flat bed, open curtain side or rigid box)*	**12 000**	

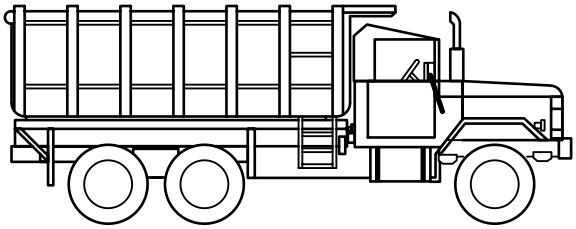
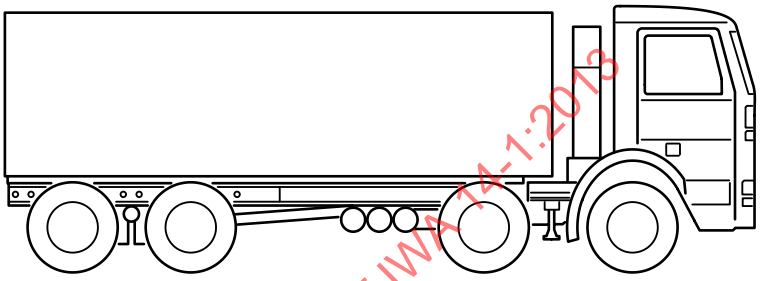
Type of test vehicle	Vehicle classification and description	Test vehicle mass (kg)	Illustration
	N3E 29 500 kg 3-axle rigid	**24 000**	
	N3F 32 000 kg 4-axle rigid	**30 000**	

Figure 8 — Vehicle classifications used for vehicle impact testing

6.1.2 Winch cable or other equipment, capable of delivering the test vehicle to the VSB at the specified impact speed. It shall be capable of propelling the test vehicle in a stable manner and in a straight line, to a point where the vehicle is released and is able to travel freely until reaching the initial contact point.

NOTE Experience has shown this release point should be determined in accordance with the longitudinal position of the winch attachment device to the test vehicle. This ensures the test vehicle is travelling freely for speed measurement purposes and impact.

6.1.3 Equipment for measuring speed, capable of measuring the freely moving vehicle's impact speed along the vehicle approach path (before the initial contact point) to an accuracy of ± 2 %.

NOTE 1 The maximum distance between the measurement being taken and initial contact point is given in 6.7.3a).

NOTE 2 A minimum of two independent methods of speed recording should be used. The determination of impact speed is an essential parameter. Suitable methods could include a timing gate, determination of winch cable speed, the use of "pressure pads" activated by the passage of the test vehicle, the analysis of high-speed film records or attaching a calibrated "fifth wheel" to the test vehicle.

6.1.4 Equipment for measuring impact angle, capable of measuring angles to an accuracy of ± 1°.

NOTE Suitable equipment can include overhead high-speed cameras and appropriate ground reference lines (see 6.2.5).

6.1.5 Equipment for measuring distance, capable of measuring to an accuracy of ± 2 %.

6.1.6 Equipment for measuring mass (not including major debris), capable of measuring mass to an accuracy of ± 50 kg.

6.1.7 Equipment for measuring major debris, capable of measuring mass to an accuracy of ± 1 kg.

Table 1 — Test vehicle specification

Vehicle classification	M1	N1G	N1	N2A	N2B	N3C	N3D	N3E [I]	N3F [I]
Type of test vehicle [A]	Car	4x4 crew cab pick-up	Day cab vehicles [E]						
			Flat bed [H]	2-axle rigid	2-axle rigid	2-axle rigid	2-axle rigid	3-axle rigid	4-axle rigid
Test vehicle mass (kg)	1 500	2 500	3 500	7 200			12 000	24 000	30 000
Minimum unladen mass (kg)	1 235	1 700	1 675	3 575	5 200	6 100	6 200	9 750	10 500
Maximum ballast (kg)[B], [C] Maximum secured Maximum unsecured Tolerance (kg)	265 265 50 ±50	800 800 50 ±50	1 825 1 825 75 ±50	3 625 3 625 100 ±50	2 000 2 000 100 ±50	1 100 1 100 100 ±50	5 800 5 800 100 ±50	14 250 1 000 14 250 ±50	19 500 1 000 19 500 ±50
Test vehicle mass (kg) Tolerance (kg) [D]	**1 500** ±75	**2 500** ±75	**3 500** ±100	**7 200** ±400	**7 200** ±400	**7 200** ±400	**12 000** ±400	**24 000** ±400	**30 000** ±400
Vehicle length (mm)[E] Tolerance (mm)	4 500 ±360	5 200 ±600	6 200 ±380	7 610 ±1 520	8 340 ±1 670	9 560 ±1 910	8 900 ±1 900	7 640 ±1 200	9 600 ±1 000
Vehicle width (mm)[F] Tolerance (mm)	1 760 ±150	1 850 ±200	2 100 ±175	2 400 ±200	2 400 ±200	2 500 ±225	2 500 ±225	2 400 ±200	2 500 ±225
Wheel base (mm)[G] Tolerance (mm)	2 700 ±540	3 200 ±500	3 805 ±710	4 310 ±830	5 275 ±1 100	5 910 ±1 250	5 450 ±1 250	5 600 ±500	6 800 ±500
Height from ground to lowest edge of the chassis rail at the front (mm) Tolerance (mm)	n/a	435 ±75	440 ±120	515 ±175	630 ±175	750 ±200	845 ±225	750 ±200	810 ±200

[A] The types of vehicle are illustrated in Figure 8.

[B] Where instrumentation is used, it forms part of the secured ballast (see 6.5.7).

[C] When an anthropomorphic dummy (ATD) is used in the test, it shall be 75 kg and shall be installed and seat belted. The ATD mass shall not contribute to the test vehicle mass, therefore the ATD shall be added after the test vehicle mass has been set within tolerance.

[D] Tolerances for N2A, N2B and N3C vehicles allow comparisons with other impact test publications (e.g. ASTM F 2656, CWA 16221 and PAS 68). Otherwise, the test vehicle mass should be as close as is practicable to 7 200 kg.

[E] Including an attached load bed.

[F] Not including mirrors.

[G] Length between the extreme axles.

[H] Rear wheel drive.

[I] If necessary, container vehicles (N3E and N3F) can be completely loaded with unsecured ballast to meet the test vehicle mass (see 6.5.5).

6.1.8 Video photographic equipment, capable of recording:

a) the behaviour of the VSB;

b) the test vehicle motion pre-impact from a minimum of 8 m before the initial contact point and post-impact to a minimum of 25 m beyond the VSB datum line;

c) the ballast (secured and unsecured) during impact so as their motion can be filmed; and

NOTE Where the test vehicle has a rigid box, one way of observing the ballast is to install an onboard camera.

d) any movement and/or rotation of the foundation.

High-speed camera systems shall be operated at a minimum of 200 frames per second and be capable of producing noise-free, correctly exposed[1)] results in year round outdoor lighting conditions without resorting to the use of electronic gain or non-standard film processing to correct the exposure. The cameras shall be fitted with lenses of a flat field type in order to minimize any distortion of the image; these lenses shall be of a (photographic) quality capable of achieving the optimum sensor, or film, resolution of the camera.

NOTE 1 In order to minimize distortion, for the overhead photography, a lens with a focal length of 9 mm or longer used with 16 mm cine (or equivalent) should be used.

NOTE 2 A higher recording frame rate, for example, 500 frames per second, gives greater detail of the test vehicle and VSB impact, but could decrease the resolution and require higher light levels.

The **minimum** number of cameras and layout shall be as follows, as illustrated in Figure 9:

A. a high-speed static camera (see Figure 9, Camera A), ground based, in-line with the VSB and with an unobstructed view of the VSB impact face;

NOTE This camera is used to determine the height of the initial contact point and/or target impact point, dynamic vehicle penetration distance, the impact speed and the post-impact speed of the test vehicle. Characteristics of the test vehicle impacting into the VSB can also be recorded.

B. a high-speed static camera (see Figure 9, Camera B), ground based, in-line with and facing the vehicle approach path;

NOTE This camera is used to determine if the target impact point/initial contact point is within the tolerance and to show the characteristics of the test vehicle impacting into the VSB. The impact angle determines whether the target impact point or initial contact point is used to assess the impact accuracy [see 6.3].

C. where the impact angle is being measured by use of photographic equipment only and by no other means, an overhead high-speed static camera(s) [see Figure 9, Camera C], located in such a way as to cover the test vehicle motion from a minimum of 3 m before the initial contact point and a minimum of 5 m past the VSB datum line.

NOTE If the only method to measure impact angle is an overhead camera(s), and weather conditions mean it is dangerous to deploy and/or operate an overhead camera(s), the test should be delayed until it is safe to proceed.

NOTE If it is not possible to view the specified area with one camera, then an additional overhead camera is required.

NOTE Camera C may be used to record the impact angle, the static and dynamic vehicle penetration distances, and the major debris distance/coordinates up to a minimum of 5 m past the VSB datum line.

1) Correctly exposed - ensuring that the brightness range of the area of interest is captured in its entirety. This is achieved through understanding (and utilization) of the camera variables (i.e. aperture, shutter speed, frame rate, sensor/film sensitivity).

NOTE Overhead high-speed static cameras can be used to measure the impact angle. Other methods of measuring the impact angle, such as global positioning satellite (GPS), may be used.

Where cameras are used for determining impact speed, a time reference shall be recorded by the camera.

NOTE 3 For example, distance marks at ground level, timing light, timing drum or timing marks made within the camera.

The **recommended** number of cameras (informative), in addition to the minimum camera layout (cameras A, B and C), are illustrated in Figure 9:

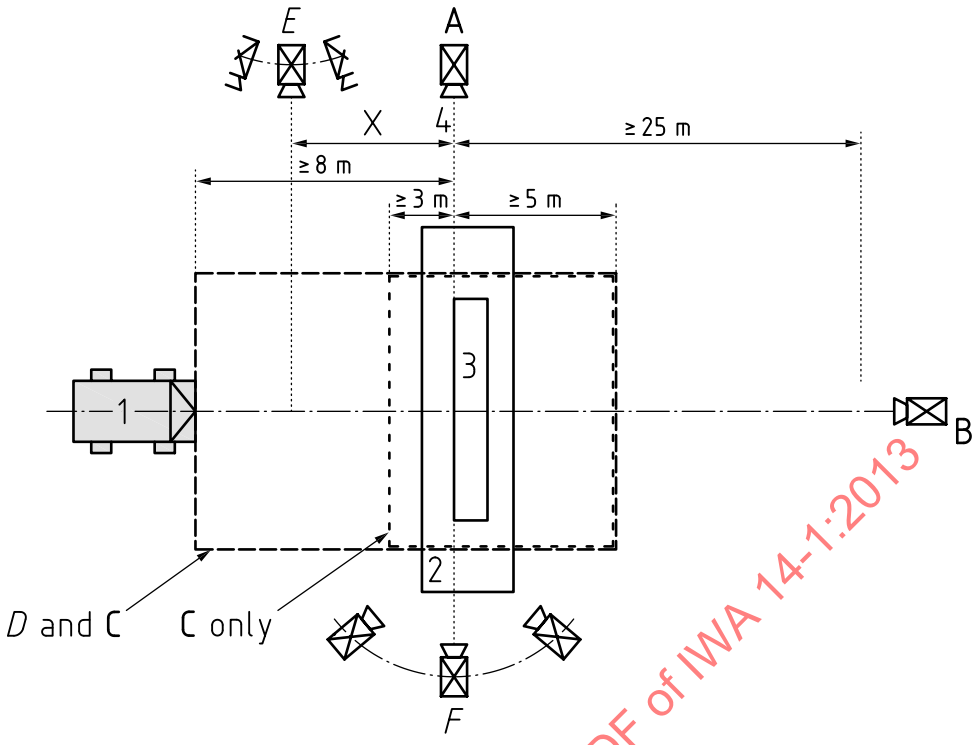
NOTE 4 To reduce the risk of no data capture due to camera failure and to provide a greater insight into the test vehicle impacting the VSB, the use of additional cameras is recommended. Additional cameras can include the following as illustrated in Figure 9 (alongside required cameras):

D. a second overhead high-speed static camera (see Figure 9, Camera D) – the use of two overhead high-speed static cameras (see Figure 9) would involve a different layout to the use of a single overhead camera and should capture a minimum of 8 m before the initial contact point and a minimum of 5 m beyond it.

E. a real time panning camera (see Figure 9, Camera E), sited at right angles to the vehicle approach path. This camera is to record the test vehicle and the VSB interaction in real time pre-, during and post-impact.

F. a high speed static camera (see Figure 9, Camera F), ground based, to record the interaction of the test vehicle and the VSB. Location to be agreed by the test house and the client.

NOTE 5 Additional high-speed cameras can be used as backups and/or to provide extra viewing points where the VSB has specific components that need to be assessed (e.g. the foundations, hinges). The test house and the client should agree on the location of such cameras.



Camera	Required or recommended	Description
A	Required	high-speed static camera, ground based, in-line with the VSB and with an unobstructed view of the VSB impact face
B	Required	high-speed static camera, ground based, in-line with and facing the vehicle approach path
C	Required	overhead high-speed static camera that covers the test vehicle motion from a minimum of 3 m before the VSB datum line and a minimum of 5 m past the VSB datum line
D	Recommended	overhead high-speed static camera that in conjunction with Camera C covers the test vehicle motion from a minimum of 8 m before the VSB datum line and minimum of 5 m past the VSB datum line
E	Recommended	real time panning camera, sited at right angles to the vehicle approach path
F	Recommended	high speed static camera, ground based, to record the interaction of the test vehicle and the VSB

Key

1	test vehicle	4	VSB datum line
2	VSB foundation	X	distance between one and two test vehicle lengths
3	VSB		

NOTE 1 Cameras A, E and F are illustrated as being on particular sides of the VSB, but they can equally be positioned on the opposite sides of the vehicle centre line, although cameras A and F should not be on the same side.

NOTE 2 The distance X (from the initial contact point to camera E) depends on the test vehicle used. For example, using an N2A test vehicle with a total vehicle length 7,61 m implies that X is between 7,61 m and 15,22 m.

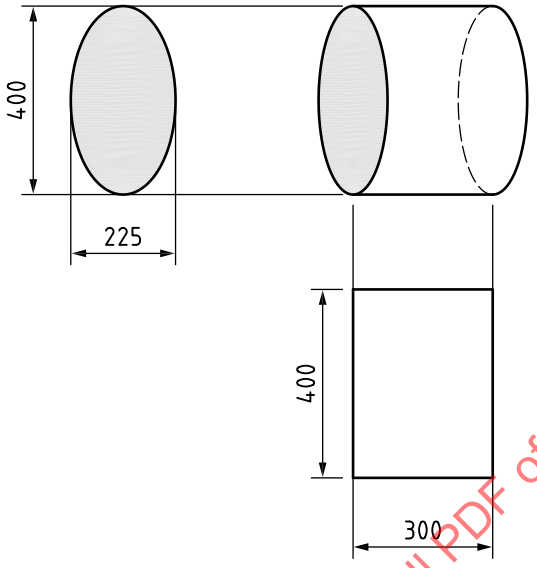
Figure 9 — Layout for required and recommended cameras

6.1.9 Pedestrian intruder test block**, conforming to the dimensions given in Figure 10**

NOTE 1 Examples of VSBs that can be assessed using this method are fences, security shutters, gates and stiles intended for controlling both vehicular and pedestrian access.

NOTE 2 This equipment is only required if pedestrian intruder access data are required.

Dimensions in millimetres



NOTE The test block shape and size has been sourced from LPS 1175.

Figure 10 — Pedestrian intruder test block (normative, where pedestrian intruder access is assessed)

6.2 Test site

6.2.1 The test site ground 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 to the required speed and controlled so that the vehicle approach path to the VSB is stable (negligible roll, pitch and yaw).

6.2.2 The test site ground used for the test, the VSB and the foundation to the VSB shall have a level surface and shall be clear of standing water (e.g. puddles), ice and/or snow at the time of the test.

6.2.3 Measures shall be taken in order to minimize dust or water spray generation from the test site ground and the test vehicle during the impact test so that photographic records are not obscured.

6.2.4 To enable the test vehicle exit characteristics to be evaluated, the test site ground shall extend not less than 25 m beyond the rear face of the VSB and shall be firm and free of obstructions (e.g. equipment, stored materials, redundant VSBs).

6.2.5 The test site ground shall be marked to indicate the VSB datum line and for the post-impact determination of the vehicle penetration distance (static and dynamic), the major debris distance and major debris coordinates.

NOTE 1 Suitable means of marking the test site ground with a contrasting colour include painting lines and using grids or target markers.

NOTE 2 Markings indicating nominal distances beyond the VSB datum line (e.g. 1 m, 2 m, 3 m, 4 m, 5 m; see Figure 5), can be used as a visual aid for setting up the overhead camera(s) and for assisting in the measurement of the vehicle penetration distance (static and dynamic), the major debris distance (see Figure 6) and major debris coordinates (see Figure 7).

6.3 Target impact point, initial contact point and impact angle

6.3.1 Target impact point

6.3.1.1 Where the impact angle is > 45°, the target impact point shall be achieved to an accuracy in accordance with Table 2.

NOTE 1 The target impact point is defined as the intersection between the longitudinal centre line of the test vehicle and the prescribed lateral position on the VSB impact face (see 3.5.3).

NOTE 2 In the case of bollards (passive or active) the impact angle and the target impact point should take into account design features of the bollard (e.g. symmetry and construction) and its foundation design (e.g. reinforcement and bollard installation).

6.3.1.2 The reason for choosing the target impact point location on the VSB shall be stated in the test report (see 6.8.1).

NOTE For any VSB, consideration should be given by interested parties (e.g. end user, test house, client, suitably experienced specialist) to assessing how the location of the target impact point affects its performance when subjected to a vehicle impact test. Design features (e.g. hinges, joints, beams, proprietary foundations) could reduce a VSB's capability to resist the test vehicle's progression.

6.3.2 Initial contact point

Where the impact angle is ≤ 45°, the initial contact point (see 3.5.4) shall be used to assess the accuracy of the vehicle impact and shall be achieved to an accuracy in accordance with Table 2.

NOTE Being within the initial contact point tolerance (see Table 2) is difficult to achieve for shallow impact angles (i.e. ≤ 45°) due to a small angular change moving the lateral position of the initial contact point along the VSB impact face. Being within the impact angle tolerance (see 6.3.3) does not necessarily mean the initial contact point is within tolerance.

Table 2 — Target impact point/initial contact point accuracy for all impact angles

VSB impact face [A] **width, *w*** [B] mm	**Accuracy** mm
$w < 400$	±100
$400 \leq w < 1\,500$	±150
$1\,500 \leq w$	±300

NOTE 1: For example, a planter with an impact face width of 1 400 mm being hit by a test vehicle at an impact angle of 90°, has a target impact point accuracy of ± 150 mm.

NOTE 2: For example, a bollard with an impact face width of 200 mm being hit by a test vehicle at an impact angle of 30°, has a initial contact point accuracy of ± 100 mm.

[A] The part of the VSB structure designed to withstand the impact.

[B] Dimension facing the vehicle approach path, usually referred to as the width. For example, diameter of a bollard, width of a blocker, length of a gate beam.

6.3.3 Impact angle

The impact angle shall be:

a) 90° to the VSB datum line; or

b) the angle to the VSB datum line that on testing is most likely to cause failure in conforming to Clause 4, where 90° does not represent this; or

c) where testing a VSB for use at a specific site, an angle between 5° and 85° to the VSB datum line at 5° increments (i.e. 5°, 10°, 15° … 75°, 80° or 85°).

The impact angle shall be achieved within a tolerance of ± 2°.

NOTE Testing at a shallow impact angle (e.g. ≤ 45°) could decrease the accuracy of the initial contact point (see Note to 6.3.2).

6.4 VSB preparation

6.4.1 General

6.4.1.1 Photographs shall be taken to record the preparation and installation of the VSB and its foundation.

6.4.1.2 The VSB shall be of contrasting colour to the test vehicle and the surroundings.

NOTE The VSB may need to be painted an appropriate colour to aid visibility in the camera footage.

6.4.2 Installation

6.4.2.1 The VSB shall be installed in accordance with the detailed drawings and installation instructions provided in accordance with 5.1. Any conformance discrepancies shall be addressed in accordance with 5.2.

NOTE 1 Depending on the VSB, installation could involve location of the VSB in a VSB foundation or directly on the test site ground (see Figure 1).

NOTE 2 The VSB should be installed in the orientation specified in the documentation [see 5.1g)].

NOTE 3 If a proprietary foundation is being designed for the VSB, advice should be sought from a suitably qualified civil and/or structural engineer.

6.4.3 Rigid foundation

6.4.3.1 Where concrete is used to form the VSB foundation, samples (e.g. cubes) shall be tested for strength in accordance with either EN 12390-2 or ASTM C39 / C39M.

NOTE If the test site temperature is low (<10 °C), this may increase the curing time of concrete. Consideration should be given to:

a) allowing more time for curing; or, failing that:

b) adding a chemical accelerant to the concrete mix; or

c) insulating/covering the concrete.

6.4.3.2 A sample shall be tested within ± 24 h of the test day. The concrete strength of the sample taken within ± 24 h of the test day shall be recorded with the number of days since the concrete was poured.

6.4.3.3 Where the test day is ≥ 28 days from the concrete being poured, the 28 day strength shall be declared as the minimum 28 day strength required for installation of the VSB.

6.4.3.4 The frequency of testing the concrete strength of the sample shall be in accordance with Table 3.

Table 3 — Concrete sample testing schedule

Time between concrete pour and test day	Day sample is tested			
Days	Day 7	Day 14	Day 28	Test day
0 – 7	–	–	yes	yes
8 – 14	yes	–	yes	yes
15 – 27	yes	yes	yes	yes
≥ 28	yes	yes	yes	–

NOTE 1 Samples are tested at intervals after the installation date (i.e. after the concrete has been poured), to allow the curing rate to be monitored and to determine the concrete strength. For example:

a) If the test day is 5 days after the concrete is poured, samples are tested at 5 days (the test day) and 28 days.

b) If the test day is 11 days after the concrete is poured, samples are tested at 7 days, 11 days (the test day) and 28 days.

c) If the test day is 17 days after the concrete is poured, samples are tested at 7 days, 14 days, 17 days (the test day) and 28 days.

d) If testing ≥ 28 days after the concrete is poured, samples are tested at 7 days, 14 days and 28 days.

NOTE 2 Recording the concrete strength at 28 days is necessary to give a consistent means to compare installations, irrespective of when the vehicle impact test was carried out.

6.4.3.5 Where multiple batches of concrete are required for the installation, for each batch of concrete, the concrete strength and the location of where it was poured in the installation shall be recorded.

NOTE Samples should be taken from each concrete batch and tested in accordance with 6.4.3.1.

6.4.4 Non-rigid foundation

6.4.4.1 Soil grade and bearing capacity

Where soil is used to form the VSB foundation, the soil grade and bearing capacity shall be measured and recorded.

NOTE Example soil specifications can be found in ASTM F 2656, AASHTO's Standard specification for materials for aggregate and soil-aggregate subbase, base, and surface courses, and BS EN 12767:2007, Annex A.

6.4.4.2 Compaction and moisture content

Where soil is used to form the VSB foundation, the compaction and moisture content shall be measured and recorded not more than 72 h before the test.

NOTE The soil compaction can be recorded by nuclear density testing or the California Bearing Ratio (CBR); one method for calculating the CBR is the dynamic cone/drop weight penetrometer. The soil moisture content can be measured using a moisture meter.

6.4.5 Markers

6.4.5.1 A marker shall be applied to the target impact point (for an impact angle > 45°) or initial contact point (for an impact angle of ≤ 45°) on the VSB so as to be visible by Camera B [see 6.1.8, B].

NOTE This is to assist in measuring and verifying the target impact point or initial contact point [see 6.3].

6.4.5.2 If the VSB (e.g. a bollard) is intended to be part of an array but is being tested individually, markers that remain stationary during the impact shall be put down either side of the VSB, along the VSB datum line, giving a 1 200 mm gap between the VSB and marker.

NOTE These markers are to aid in the evaluation of the post-impact vehicle access [see 6.7.4.7] by indicating the intended locations of other VSBs in the array.

6.5 Test vehicle preparation

6.5.1 General

The test vehicle shall be of contrasting colour to the VSB and the surroundings to aid visibility in the camera footage.

NOTE Experience has shown that when the contrast is poor, the test vehicle might need to be painted an appropriate colour to improve contrast. M1 and N1G test vehicle exteriors should be completely painted. N1, N2 and N3 test vehicles should have the cab painted as a minimum.

6.5.2 Test vehicle dimensions

The test vehicle dimensions shall be verified against the test vehicle specification (see Table 1) for the dimensions (in mm) and details in accordance with Annex A.

6.5.3 Vehicle condition

6.5.3.1 The tyres shall be inflated to the tyre manufacturer's recommended pressures.

6.5.3.2 The test vehicle shall be as clean as is reasonably practicable and any deposits that might cause dust on impact shall be removed prior to testing.

6.5.4 Secured ballast

6.5.4.1 All secured ballast shall be located symmetrically about the centre-line of the test vehicle and be evenly distributed.

6.5.4.2 For N1G, N1, N2 and N3 test vehicles, the secured ballast shall be braced against the front of the load bed.

6.5.4.3 The secured ballast shall be fixed to the test vehicle such that it is rigidly held to the load bed (for N1G, N1, N2 and N3 test vehicles) and remains fixed up to the moment of impact.

NOTE Significant movement of the secured ballast could change the behaviour of the test vehicle and so affect the results. Experience has shown that when testing at ≥ 80 km/h (≥50 mph), it is difficult to ensure the secured ballast remains rigidly held to the vehicle/load bed. Best practice methods of securing the ballast during impact include using chains, fixed frames and bolting down to the load bed.

6.5.4.4 The vehicle axle weight limits for the test vehicle shall not be exceeded when the test vehicle is ballasted.

6.5.5 Unsecured ballast

All unsecured ballast in the N3E and N3F test vehicles shall be evenly distributed so as not to exceed vehicle axle weight limits.

6.5.6 Reference points

6.5.6.1 The vehicle datum point shall be marked with a reference point (e.g. quartered target marker). For an N1, N2 or N3 test vehicle, additional reference points on the chassis shall be made towards the rear of the test vehicle (if the chassis is visible) and their longitudinal distances from the vehicle datum point recorded. These reference points shall be visible to Camera A (see 6.1.8, A).

NOTE A reference point on the chassis enables the vehicle datum point to be determined if the front of the test vehicle/chassis is distorted due to the test vehicle impact with the VSB.

6.5.6.2 A reference point(s) (e.g. quartered target marker) shall be applied to the centre-line of the test vehicle so as to be visible by the head-on camera and an overhead camera (see 6.1.8, B and C respectively).

6.5.6.3 A reference point(s) (e.g. quartered target marker) shall be applied to the target impact point (for an impact angle > 45°) or initial contact point (for an impact angle of ≤ 45°) on the VSB so as to be visible by Camera B (see 6.1.8, B).

NOTE 1 This is to assist in measuring and verifying the target impact point (see 6.3).

NOTE 2 Where the VSB is tested in an array (e.g. twin bollards), reference points should be placed on the test vehicle, corresponding to the extremities of the gap between the VSBs (i.e. the inside edges of the bollards), so as to be visible by Camera B (see 6.1.8, B).

6.5.7 Occupant injury

Where the determination of occupant severity indices are requested (optional), measurement and recording equipment (see Note to 6.7.1.3) shall be attached.

NOTE The acceleration severity index (ASI) and theoretical head impact velocity (THIV) are examples of occupant severity indices.

6.6 Impact speed

The impact speed shall be selected from Table 4.

NOTE To translate systems operating in miles per hour (mph), the conversion factor between km/h and mph is 1 km/h = 0.621 mph.

Table 4 — Vehicle impact speed

		Impact speed (km/h) [A]						
		16^{+3}_{-1}	32^{+3}_{-1}	48^{+3}_{-1}	64^{+3}_{-1}	80^{+4}_{-2}	96^{+4}_{-2}	112^{+4}_{-2}
Vehicle classification	M1	yes	yes	yes	yes	yes [B]	yes [B]	yes [B]
	N1G	yes	yes	yes	yes	yes [B]	yes [B]	yes [B]
	N1	yes	yes	yes	yes	yes [B]	yes [B]	no
	N2	yes	yes	yes	yes	yes [B]	no	no
	N3	yes	yes	yes	yes	yes [B]	no	no

[A] The impact speed shall be stated in km/h in the test report.

[B] Experience has shown that at ≥ 80 km/h (≥50 mph), it is difficult to ensure that the secured ballast remains rigidly held to the vehicle/load bed (see 6.5.4.3).

6.7 Test procedure

6.7.1 Pre-impact data

6.7.1.1 VSB foundation

For the VSB foundation, record:

a) date foundation was cast;

b) results of test samples in accordance with 6.4.3;

c) type of foundation (generic, proprietary, integral as defined in 3.2).

6.7.1.2 VSB

For the VSB, record:

a) height of the initial contact point from ground level;

NOTE Typically the initial contact point is where the test vehicle front bumper first touches the VSB impact face (see 3.5.4).

b) the angle of the impact face with respect to the horizontal plane for bollards, gate posts and latch points;

c) the angle of the impact face with respect to the VSB foundation for bollards, gate posts and latch points (normally 90°);

d) location within foundation and installation depth;

e) for an active VSB, using a real time camera, the operating cycle (e.g. rising/lowering/sliding/swinging), state the functionality [see 5.1n) and 5.1o)] and the means by which it is operated for the test (e.g. powered or manual).

f) photographs, including those at 90° and 45° to the impact face of the VSB.

NOTE 1 Photographs should be taken of all faces of the VSB (i.e. from north, south, east and west).

NOTE 2 Photographs should be taken of specific design features of a VSB (e.g. hinges, pins, joints, welds) to aid test data analysis.

6.7.1.3 Test vehicle

For the test vehicle, record:

a) mass to a tolerance as specified in Table 1;

b) dimensions in accordance with Annex A to a tolerance as specified in Table 1 (where a tolerance is specified);

NOTE Measurements of the test vehicle are recorded to aid test data analysis and comparability with other tests.

c) for nominal test vehicle masses 1 500 kg (M1) and 2 500 kg (N1G) to a tolerance as specified in Table 1, the location of the centre of gravity of the test vehicle in the test condition including added ballast;

NOTE ISO 10392 specifies methods for determining the location of the centre of gravity of a road vehicle.

d) for nominal test vehicle masses 3 500 kg (N1), 7 200 kg (N2A, N2B and N3C), 12 000 kg (N3D), 24 000 kg (N3E) and 30 000 kg (N3F) to a tolerance as specified in Table 1, the location of the centre of gravity of the added ballast;

NOTE ISO 10392 specifies methods for determining the location of the centre of gravity of a road vehicle.

e) exterior photographs of the test vehicle, including those at 90° and 45° to the longitudinal vehicle axis and VSB (and interior of the vehicle if required to aid an assessment of occupant injury);

f) photographs of the test vehicle positioned next to the VSB at the target impact point; including 90° and 45° to the longitudinal vehicle axis and VSB.

NOTE Angular rate sensors can be used for determining the yaw, roll and pitch of the test vehicle (which can aid analysis of test data). Accelerometers and angular rate sensors are required for determining occupant severity indices (see EN 1317–1:2010 or AASHTO's manual, MASH-1 for the method).

6.7.1.4 Target impact point and angle

NOTE The impact angle dictates whether the target impact point or initial contact point is marked and used for accuracy purposes (see 6.3.1).

Record for an impact angle > 45°:

a) the height of prescribed target impact point from ground level;

b) the distance of prescribed target impact point(s) from the centre point of the VSB; and

NOTE 1 For 90° vehicle impacts, the planned distance between the target impact point and centre point of the VSB should be 0 mm, e.g. for a single bollard test.

NOTE 2 For two adjacent VSBs, where the test vehicle is directed towards the gap at an impact angle of 90°, two planned initial contact points (one on each VSB) should be measured with respect to the centre point of the gap between the VSBs.

c) the impact angle.

Record for an impact angle ≤ 45°:

1) the height of prescribed initial contact point from ground level;

2) the distance of prescribed initial contact point from the centre point of the VSB; and

3) the impact angle.

6.7.1.5 Cameras

Record:

a) the camera specifications (e.g. real time/high speed and the recording frame rate, i.e. real time: 24 frames per second, high speed: 200 frames per second); and

b) the camera layout.

6.7.2 Impact

6.7.2.1 Propel the test vehicle (see 6.1.1) by winch or other suitable equipment (see 6.1.2) or by engine power in a straight line and under stable conditions up to the point of release such that it travels freely until reaching the initial contact point.

6.7.2.2 The test vehicle

a) shall be travelling freely (see 6.1.2) when measuring its impact speed [see 6.7.3a)];

NOTE The impact speed recording equipment may be positioned up to 5 m from the initial contact point [see 6.7.3a)], therefore the point at which the test vehicle commences travelling freely needs to be prior to the impact speed measuring point.

b) shall not be restrained by external control of the steering or any other method (e.g. by engine power or by braking) pre-impact, during or post-impact, while the test vehicle is within 25 m of the VSB datum line (unless the test vehicle poses a safety or operational risk).

6.7.2.3 At least one camera (high-speed or real time) shall cover the test vehicle motion from a minimum of 8 m before the initial contact point and post-impact to a minimum of 25 m beyond the VSB datum line.

6.7.3 Impact data

Record the following impact data:

a) impact speed (km/h), using equipment for measuring speed (see 6.1.3) along the vehicle approach path no further than 5 m before the initial contact point;

b) impact angle (degrees), using equipment for measuring angles (see 6.1.4);

NOTE Methods of measuring the impact angle include overhead photography (see 6.1.8, C).

c) target impact point/initial contact point (depending on impact angle, see 6.7.1.4), using equipment for measuring distance (see 6.1.5):

1) height of contact between the test vehicle (e.g. mid height of bumper) and VSB from ground level;

2) record the distance along the VSB impact face from the prescribed target impact point/initial contact point to the actual impact point/initial contact point (refer to 6.7.2), using reference points on the test vehicle and VSB (see 6.5.6);

d) pre-impact, during and post-impact behaviour of the VSB and test vehicle motion up to 25 m beyond the VSB datum line, as well as the distribution of major debris using photographic equipment (see 6.1.8);

e) if data acquisition equipment is used, the amount of occupant injury can be assessed using occupant severity indices (see 6.5.7).

6.7.4 Post-impact data

6.7.4.1 Photography

Take still photographs *in situ* of:

a) the test vehicle axes at 90° and 45° (at eye-level, e.g. typically 1,5 m to 1,9 m above test site ground level);

b) the interior and exterior of the test vehicle;

c) VSB and foundation (at eye-level);

d) test vehicle (at eye-level);

e) major debris and other debris (at eye-level);

f) VSB, test vehicle and major debris in the same frame (at eye-level).

NOTE 1 Photographs should be taken of all faces of the VSB and the test vehicle (i.e. from north, south, east and west).

NOTE 2 Photographs should be taken of specific design features of a VSB (e.g. hinges, pins, joints, welds) and points of interest post-impact, such as fractures, breaks, buckles, to aid test data analysis.

NOTE 3 Each photograph should have a unique reference attached to it (e.g. test number) to aid the analysis of test data.

6.7.4.2 Vehicle penetration distance

Record the vehicle penetration distance (static and dynamic).

NOTE 1 For the majority of tests, the vehicle penetration distance is measured according to Figure 5a). In the instance where there is > 90° yaw and/or pitch, measurements follow the example of Figure 5b).

NOTE 2 Vehicle penetration distance is also illustrated in Figure 11 alongside VSB foundation displacement.

6.7.4.3 Major debris

Record as an observation, the major debris distance and major debris coordinates using distance measurement equipment (see 6.1.5).

NOTE 1 Major debris either side of the VSB datum line is recorded but does not form part of the VSB performance rating classification code as specified in Clause 7.

NOTE 2 Major debris distance and major debris coordinates are illustrated in Figure 6 and Figure 7.

6.7.4.4 Damage and distortion

Record any damage and distortion to the:

a) VSB;

b) VSB foundation;

c) test vehicle.

Record any irregularities in the gap between the VSB and its foundation with and without the test vehicle in place (as necessary).

NOTE 1 In the event of the VSB being displaced and the foundation remaining stationary, measurements of the VSB displacement relative to its pre-impact position and the foundation should be recorded as an observation.

NOTE 2 Examples of damage/distortion to record include detached components, foundation cracks and vehicle bodywork. For bollards, gate posts and beams, an example of damage/distortion includes deformation of sections.

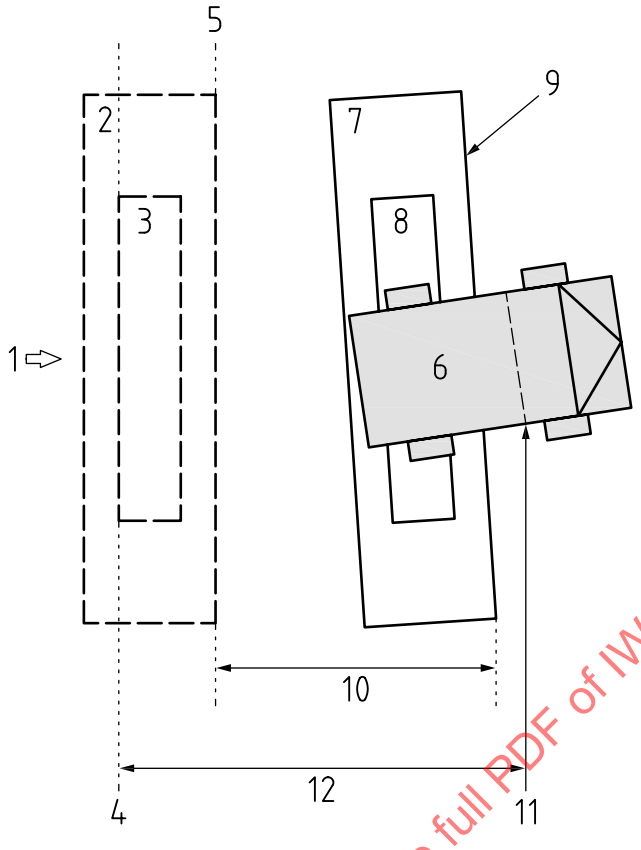
6.7.4.5 VSB foundation displacement distance and angle

Record the VSB foundation displacement distance and angle with and/or without the test vehicle in place.

NOTE 1 It might not be possible to measure the VSB foundation displacement distance and angle with the test vehicle in place.

NOTE 2 The VSB foundation displacement angle is the angle of inclination of the foundation to the test site ground. The incline of the test site should be accounted for when recording the VSB foundation displacement angle, i.e. using it as a pre-test reference point. The VSB foundation displacement distance and angle are illustrated in Figure 11, Figure 12 and Figure 13.

NOTE 3 This post-test data may be recorded on a copy of the original engineering drawing to aid test analysis.

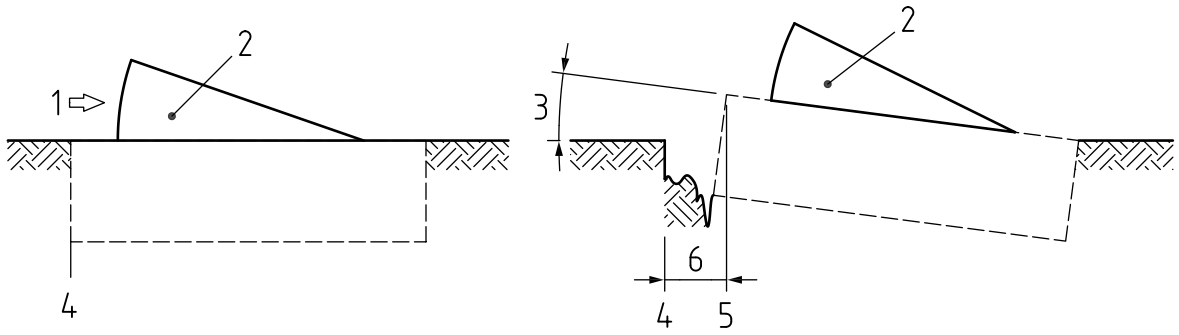


a) Pre-impact **b) Post-impact**

Key

1	direction of impact	7	VSB foundation
2	VSB foundation	8	VSB
3	VSB	9	rear face of VSB foundation
4	VSB datum line	10	VSB foundation movement
5	rear face of VSB foundation	11	vehicle datum point
6	test vehicle	12	vehicle penetration distance

Figure 11 — VSB foundation displacement distance and vehicle penetration — Aerial view



a) Pre-impact **b) Post-impact**

Key

1	direction of impact	4	pre-impact position of front face of VSB foundation
2	VSB (e.g. blocker)	5	post-impact position of front face of VSB foundation
3	VSB foundation displacement angle (degrees)	6	VSB foundation displacement distance

NOTE In the figure, for simplicity, the VSB foundation displacement distance is shown as being the distance between the pre-impact and post-impact front face of the VSB foundation. In practice, this distance is typically measured from the rear face of the VSB, as the front face of the VSB foundation might be obscured, for example, by the test vehicle.

Figure 12 — VSB displacement distance and VSB foundation displacement angle excluding bollards — Side view

6.7.4.6 Foundation strength

Where test samples of the foundation are taken on the day of test (±24 h) and other selected days (see 6.4.3.4), record the results of test samples obtained in accordance with 6.4.3.

6.7.4.7 Post-impact vehicle access

Where post-impact vehicle access data are required, record the size and type of any deformation to the VSB, measured with reference to a vertical plane from the base of the VSB in its pre-impact position, the maximum horizontal distortion/displacement at 0,1 m intervals taken from finished ground level to 0,6 m above finished ground level:

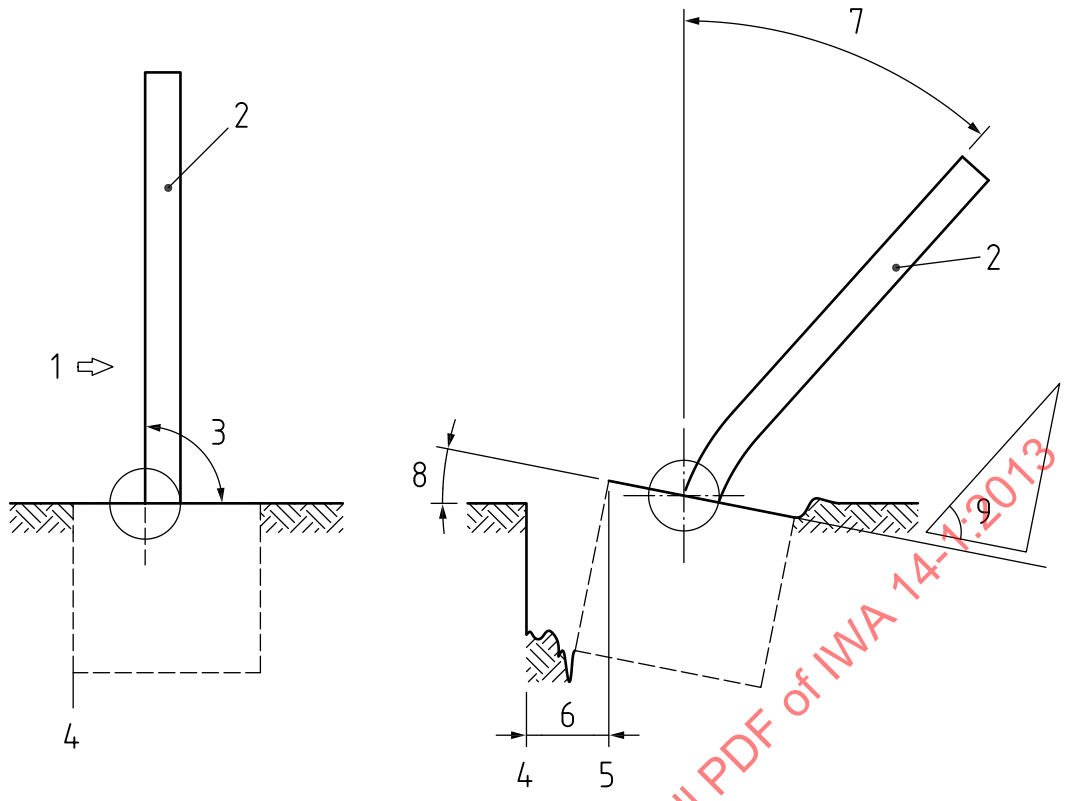
a) with the test vehicle remaining in its post-test location; then

b) where the test vehicle can be removed by a self-powered means.

NOTE 1 Post-impact vehicle access is illustrated in Figure 14.

NOTE 2 A gap of > 1,2 m between the VSB components (e.g. an array of bollards or planters) measured at 0,6 m above finished ground height is deemed to be traversable by a second vehicle. The VSB should not deform as a consequence of the impact in such a manner that a gap of > 1,2 m measured at 0,6 m above finished ground height is created.

NOTE 3 If gap measurements are ≤ 1,2 m between VSB components measured at 0,6 m above finished ground level, or any gaps are ≤ 1,2 m due to the presence of the test vehicle, then it may be classified as being part of the VSB, in which case there may be no post-impact vehicle access.



a) Pre-impact **b) Post-impact**

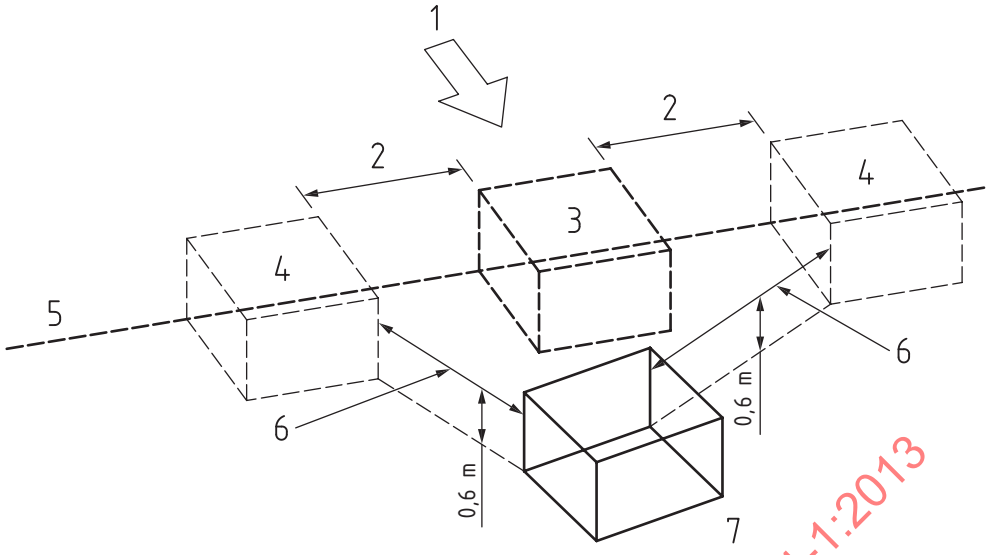
Key

1	direction of impact	6	VSB foundation displacement distance
2	VSB (e.g. bollard)	7	VSB displacement angle (degrees)
3	VSB angle, pre-test (degrees)	8	VSB foundation displacement angle (degrees)
4	pre-impact position of front face of VSB foundation	9	rotation of VSB with respect to VSB foundation (degrees)
5	post-impact position of front face of VSB foundation		

NOTE 1 Item 6: In the figure, for simplicity, the VSB foundation displacement distance is shown as being the distance between the pre-impact and post-impact front face of the VSB foundation. In practice, this distance is typically measured once the test vehicle has been removed.

NOTE 2 Item 7: The angle recorded is the greatest deflection from the vertical along the VSB impact face. This should be the sum of the VSB foundation displacement angle (item 8) and the rotation of the VSB with respect to the VSB foundation (item 9).

Figure 13 — For bollards, gate posts and beam housings: VSB foundation displacement distance and bollard displacement angle — Side view



Key

1	direction of impact	5	VSB datum line
2	pre-impact gap (typically 1,2 m)	6	post-impact gap
3	VSB pre-impact location	7	VSB post-impact position
4	neighbouring VSB		

Figure 14 — Post-impact vehicle access

6.7.4.8 Pedestrian intruder access

Where pedestrian intruder access is being assessed, test whether the full length of the pedestrian intruder test block (see 6.1.9) can be passed axially through any opening in the VSB with the test vehicle in its post-impact position.

6.7.4.9 Active VSB operation

Where the active VSB's operation with the test vehicle still in place is deemed to not cause further damage to the VSB, record the operating cycle (e.g. rising/lowering/sliding/swinging) and functionality of the VSB with the test vehicle in place.

Record the operating cycle (e.g. rising/lowering/sliding/swinging) and functionality of the VSB with the vehicle removed (as necessary).

6.7.4.10 Test vehicle alignment

For a test with a prescribed impact angle of:

a) **> 45°**: record the distance along the VSB impact face from the prescribed (not actual) target impact point to the actual impact point and determine whether it meets the accuracy specified in Table 2 (see also 6.3.1.1); or

b) **≤ 45°**: record the distance along the VSB impact face from the prescribed (not actual) initial contact point to the actual initial contact point and determine whether it meets the accuracy specified in Table 2 (see also 6.3.2).

NOTE For information about the target impact point see 6.3.1 and for the initial contact point see 6.3.2.

6.7.4.11 Occupant injury

Where occupant severity indices data are required to assess injury, evaluate the occupant severity indices by analysing test data from the instrumentation present on the test vehicle (see 6.7.1.3).

6.7.5 Further impact tests

NOTE A VSB/test vehicle may be re-used for further testing if it is determined to be fit for further evaluation, i.e. it has not been structurally weakened through testing.

A long(er) linear VSB is an example of a test piece that might undergo further testing; to test, for example, end fixings, changes in profile or other specific features of the VSB.

A test vehicle is required to meet the conditions of 6.1.1, so minor repairs may be undertaken in order facilitate its re-use.

All parties should give their approval to the re-use of a VSB/test vehicle for further testing.

6.7.6 Disposal of the VSB and test vehicle

NOTE VSBs and test vehicles should be disposed of in accordance with local, national and international regulations. Example methods of disposal are crushing and shredding.

6.8 Test report

6.8.1 General

A test report shall be prepared for each vehicle impact test.

NOTE A test report should not be released without having all the information required in Clause 5.

The test report shall include as a minimum:

a) a summary of results in accordance with 6.8.2;

b) reference to this part of IWA 14, i.e. IWA 14-1:2013;

c) name or trademark and address of the VSB manufacturer;

d) name of client (where different to the VSB manufacturer);

e) date(s) of the test(s);

f) name(s) and address(es) of the test house and their accreditation status, if relevant;

g) VSB product name, including type and model;

h) VSB product documentation (see Clause 5);

i) test impact criteria:

   1) test vehicle (country of origin, manufacturer, model, vehicle classification, test mass) (see 6.1.1);

   2) location of target impact point where impact angle > 45° or initial contact point where impact angle ≤ 45°) (see 6.3);

   3) explanation of why the target impact point or initial contact point was chosen (see 6.3.1.2);

   4) impact angle (see 6.3.3);

   5) impact speed (see 6.6);

j) test apparatus used (see 6.1);

k) VSB preparation data (see 6.4);

l) test vehicle preparation data (see 6.5);

m) test results achieved, including:

1) pre-impact data (see 6.7.1);

2) impact data (see 6.7.3);

3) post-impact data (see 6.7.4);

4) performance rating (see Clause 7).

6.8.2 Summary of results

The test report shall include a summary of results as follows:

a) General:

1) reference to this part of IWA 14, i.e. IWA 14-1:2013;

2) name or trademark and address of the VSB manufacturer;

3) name of client (where different to the VSB manufacturer);

4) date(s) of the test(s);

5) name(s) and address(es) of the test house and their accreditation status, if relevant;

6) VSB product name (type and model);

b) Inputs:

1) VSB foundation:

i) none, generic, proprietary or integral ;

ii) concrete (rigid) or soil (non-rigid);

iii) for a rigid foundation, prescribed strength of concrete (to zero decimal places);

iv) for a rigid foundation, test day strength of concrete (to zero decimal places);

v) condition;

vi) soil grade;

vii) soil compaction;

viii) soil moisture content;

ix) soil bearing capacity;

2) VSB use including array permutations;

3) test type;

4) test vehicle:

i) vehicle classification;

ii) mass (kg), to zero decimal places;

iii) supplied by (e.g. test house);

5) impact speed (km/h), to one decimal place;

6) impact angle (°), to zero decimal places;

c) Results:

1) whether the test vehicle was immobilized;

2) whether the test vehicle was restrained or deflected;

3) vehicle penetration distance:

i) dynamic (m), to one decimal place;

ii) static (m), to one decimal place;

4) IWA 14-1:2013 performance rating;

5) test parameters recorded:

i) distance from target to actual impact point/initial contact point;

ii) impact angle;

iii) impact speed;

d) Observations:

1) major debris distance (m), to one decimal place;

2) major debris coordinates, to one decimal place;

3) gap/opening:

i) vehicle (>1,2 m) (if yes, state dimensions);

ii) pedestrian intruder (gap > test block);

4) occupant injury (e.g. ASI, THIV), to one decimal place (if recorded, state occupant severity indices);

5) test vehicle kinetic energy (kJ) at impact, to one decimal place.

7 Performance rating

Where the requirements of Clause 4 are met, the VSB shall be rated in accordance with the performance rating classification code.

The performance rating classification code shall comprise the following information listed as a chain of results (e.g. IWA 14-1:2013 Blocker V/2500[N1G]/48/90:7.6, as exemplified in Table 5):

a) reference to this part of IWA 14, i.e. IWA 14-1:2013;

b) VSB;

c) test type;

NOTE This part of IWA 14 only covers one type of test, the vehicle impact test (V).

d) test vehicle mass;

e) vehicle classification;

f) impact speed;

g) impact angle; and

h) vehicle penetration distance.

Table 5 — Example of performance rating

Performance rating = IWA 14–1:2013 Blocker V/2500[N1G]/48/90:7.6		
Parameter	**Rating**	**Explanation**
VSB	Blocker	
Test type	V	Vehicle impact test
Test vehicle mass	2 500	2 500 kg
Vehicle classification	N1G	4x4 crew cab pick-up
Impact speed	48	48 km/h
Impact angle	90°	90° respectively to the impact face of the VSB
Vehicle penetration distance	7.6	the test vehicle penetrated 7,6 m beyond the VSB datum line

8 Product information

The following product information for the tested VSB shall be made available via publication:

NOTE For example, printed material or on the manufacturer's website.

a) reference to this part of IWA 14, i.e. IWA 14-1:2013;

b) VSB product name (type and model);

c) the performance rating in accordance with Clause 7.