

PAS 68:2013



BSI Standards Publication

Impact test specifications for vehicle security barrier systems

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 28, an inside back cover and a back cover.

Foreword

Publishing information

This Publicly Available Specification (PAS) was sponsored by the UK Government's Centre for the Protection of National Infrastructure (CPNI). Its development was facilitated by BSI Standards Limited and published under license from the British Standards Institution. It came into effect on 31 August 2013.

Acknowledgement is given to the following organizations that were involved in the development of this specification as members of the steering group.

- APT Security Systems
- ATG Access Limited
- Centre for the Protection of National Infrastructure (CPNI)
- Cova Security Gates Limited
- Highway Care Limited
- Hill and Smith Limited
- MIRA Limited
- Perimeter Security Suppliers Association (PSSA)
- Transport Research Laboratory (TRL).

Acknowledgement is also given to the valuable contribution made by those organizations that reviewed the working drafts of PAS 68 and who submitted comments for consideration. The contributions helped to improve the specification and are much appreciated.

Supersession

This PAS supersedes PAS 68:2010, which will be withdrawn on publication of this PAS.

Information about this document

BSI retains ownership and copyright of this PAS. BSI reserves the right to withdraw or amend this PAS on receipt of authoritative advice that it is appropriate to do so. This PAS will be reviewed at intervals not exceeding two years, and any amendments arising from the review will be published as an amended PAS and publicized in *Update Standards*.

This PAS is not to be regarded as a British Standard. It will be withdrawn upon publication of its content in, or as, a British Standard.

The PAS process enables a document to be rapidly developed in order to fulfil an immediate need in industry. A PAS may be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

This new edition of PAS 68 incorporates key technical changes only. It does not represent a full review or revision of the standard.

The following principal changes are as follows.

- Terms and definitions have been updated for clarity and to align with CWA 16221.
- Normative and informative references have been updated.
- Classification codes have been updated.
- Test classification N1G has been changed from a single to a crew cab 4x4 pick up.
- References to "weight" have been altered to "mass".

- Subclause 5.2, test methodology, Clause 7, documentation, and 8.3, impact point, have been updated to align with CWA 16221.
- Annex B, Generic rigid test foundation for a single fixed bollard for vehicle impact tests has been removed and replaced with an annex regarding VSB system classifications (see Annex A).
- Annex C has been removed as the alternative methods of impact testing listed in PAS 68:2010 edition are still being researched and developed.
- List item o) in D.1.1 has been removed as a repetition of D.1.1 l). Annex D is now Annex B.
- Some editorial amendments have been undertaken.

Relationship with other publications

PAS 68 was originally developed with PAS 69 which is guidance for the selection, installation and use of vehicle security barriers (VSBs). An international workshop agreement (IWA) is currently in development for the International Organization for Standardization (ISO) that will cover similar content to PAS 68 and PAS 69. However, both PAS 68 and PAS 69 are well established in the UK and they are being revised to meet immediate industry requirements and developments in the VSB industry since their last publication.

Product testing. Users of this PAS are advised to consider the desirability of third-party testing of product conformity with this PAS. Appropriate conformity attestation arrangements are described in BS EN ISO/IEC 17025. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this standard are drafted in accordance with *The BSI guide to standardization – Section 2: Rules for the structure, drafting and presentation of British Standards*, subclause 11.3.1, which states, "Requirements should be expressed using wording such as: 'When tested as described in Annex A, the product shall ...'". This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Particular attention is drawn to the following specific Acts:

- The Road Traffic Act 1991 [1];
- The Data Protection Act 1998 [2].

Introduction

PAS 68 has been prepared to address the needs of organizations who wish to have assurance that vehicle security barrier (VSB) systems will provide the level of impact resistance which is sought.

Many systems are available that are either promoted or considered suitable for use as VSB systems. As their characteristics differ in both function and form, a comparative means of assessing their performance is required.

This Publicly Available Specification identifies impact test methods, tolerances, test vehicle type and vehicle performance criteria that need to be met in order to conform to PAS 68. Design guidance for installing barriers is provided in PAS 69.

Declarations of conformity to PAS 68 are relevant only for the edition of the PAS to which testing was undertaken and with which all requirements were complied.¹⁾

1 Scope

This Publicly Available Specification (PAS) cites a classification system for the performance of vehicle security barriers (VSBs) and their supporting foundations when subjected to a single horizontal impact.

This PAS specifies two test methods of determining the performance classification of VSB systems:

- the vehicle impact method;
- the design method [which includes the use of finite element analysis (FEA) techniques if validated by test data].

This PAS does not cover the performance of a VSB system when subjected to blast or ballistic impact.

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.

BS EN 1317-1: 2010, *Road restraint systems – Part 1: Terminology and general criteria for test methods*

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

3 Terms and definitions

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

3.1 ballast

mass securely fixed to the vehicle

3.2 dispersion

distance beyond the VSB system datum line to the location of the furthest item of major debris (see 3.8)

¹⁾ Marking PAS 68:2013 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

3.3 fixed bollard

fixed vertical post/tube embedded into specified foundations and designed to prevent the passage of a vehicle

3.4 impact angle

angle in the horizontal plane between the intended impact face and the approach path of the test vehicle into the test item

3.5 impact point

initial point of contact between the test vehicle and the test item

3.6 inertial test vehicle mass

mass of vehicle including ballast

3.7 leading edge of goods vehicle load platform

forward edge of the upper surface of the load bed intersecting the head-board or the transverse line where the head-board would be fitted

3.8 major debris

single item having a mass of 25 kg or above, which, as a consequence of the impact has been entirely detached from:

- a) the test vehicle; or
- b) its ballast; or
- c) the VSB system;

and that has been projected beyond the original position of the VSB system datum line

NOTE Inclusion of the dispersion distance of any major debris in a test report assists with the choice of an appropriate VSB system.

3.9 test item

single or multiple items which when combined with their foundations constitute a VSB system

3.10 test system

operating equipment required for the test and specified foundations

3.11 test vehicle

production model vehicle that is representative of current traffic in the intended country of use, with an unmodified chassis, load bed and frontal structure used in an impact test to evaluate the performance of a VSB system

NOTE 1 Modifications may be made to the vehicle solely for the purpose of restraining forward movement of ballast, provided that this does not affect the dynamic behaviour of the vehicle.

NOTE 2 Further information regarding test vehicles can be found in BS EN 1317-1:2010, 5.2. BS ISO 6813 is a terminology for the collision classification of road vehicles.

3.12 test vehicle impact speed

speed of the test vehicle measured along its approach path at a point no further than 8 m before the impact point

3.13 unladen mass

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

3.14 vehicle penetration

maximum distance between the leading edge of the load platform of a day cab vehicle as marked on the chassis, or the intersection of the base of the windscreen and the "A" pillar of a car or 4x4 pickup, and the original rear face

of the VSB/VSB system datum line, when measured at 90° to the VSB system (e.g. by analyzing film, video and/or instrumentation) during or after the impact

3.15 vehicle security barrier (VSB) system

physical vehicle barrier, operating mechanism, power source and associated controls designed and installed to bring to rest or redirect an impacting vehicle

NOTE See Annex A for details of VSB system element classifications.

3.15.1 active VSB system

VSB which requires operation either by personnel or powered equipment

NOTE For example a manual dropping/lifting-arm barrier or an automated retractable/rising bollard.

3.15.2 passive VSB system

static VSB which is fixed in place or is removable using personnel or plant

NOTE For example a structural wall, a fixed bollard, a removable bollard or a planter.

4 Vehicle impact method – classification code

The VSB system elements shall be defined in accordance with Annex A.

The performance class shall be expressed in terms of a 7-part classification in accordance with Table 1.

The classification code shall include the letter V.

Table 1 Performance classification – vehicle impact test

	1	2	3	4	5	6	7
	VSB system type	V	Inertial test vehicle mass kg	Test speed km/h	Impact angle °	Vehicle penetration m	Dispersion of major debris m
<i>Example:</i>	PAS 68:2013 Fixed bollard	V	4- or 5-digit vehicle mass and test vehicle classification	2-digit or 3-digit impact speed	Any angle between 0° and 90° in 5° intervals	To 1 decimal place where X.X is the penetration	To 1 decimal place where Y.Y is the dispersion distance

Performance classes:

EXAMPLE 1

- a) PAS 68:2013 Fixed bollard V/1 500(M1)/48/90:1.7/5.2 denotes:
- 1) a fixed bollard;
 - 2) tested using the vehicle impact method;
 - 3) capable of withstanding an impact by a 1 500 kg car;
 - 4) impact speed of 48 km/h;
 - 5) impacted at 90° to the front face of the bollard;
 - 6) where the vehicle penetration was 1.7 m beyond the original position of the rear face of the bollard;
 - 7) where major debris landed no more than 5.2 m beyond the original position of the rear face of the bollard.

EXAMPLE 2

b) PAS 68:2013 Anti ram fence V/7 500(N3)/80/45:2.0/3.4 denotes:

- 1) an anti-ram fence;
- 2) tested using the vehicle impact method;
- 3) capable of withstanding an impact by a 7 500 kg goods vehicle of N3 classification;
- 4) impact speed of 80 km/h;
- 5) impacted at an angle of 45° to the front face of the fence;
- 6) where the vehicle penetration was 2.0 m beyond the original position of the rear face of the fence;
- 7) where the major debris landed no more than 3.4 m beyond the original position of the rear face of the fence.

The vehicle mass and impact speed combination shall be selected from one of the combinations specified in Table 2.

Table 2 Vehicle impact test criteria

Test vehicle classification	Test classification	Test speed	Equivalent test speed (nominal)	Impact angle	
	kg-km/h	km/h	(mph)	(°) (±2°)	
Car	M1	1 500-16	16 ±2	0° to 90° in 5° intervals	
		1 500-32	32 ±2		
		1 500-48	48 ±3		
		1 500-64	64 ±3		
		1 500-80	80 ±5		
		1 500-96	96 ±5		
		1 500-112	112 ±5		
4x4 pick-up (crew cab design)	N1G	2 500-16	16 ±2	0° to 90° in 5° intervals	
		2 500-32	32 ±2		
		2 500-48	48 ±3		
		2 500-64	64 ±3		
		2 500-80	80 ±5		
		2 500-96	96 ±5		
		2 500-112	112 ±5		
Day cab vehicles	3 500 kg flat bed (RWD)	N1	3 500-16	16 ±2	0° to 90° in 5° intervals
			3 500-32	32 ±2	
			3 500-48	48 ±3	
			3 500-64	64 ±3	
			3 500-80	80 ±5	
	3 500-96	96 ±5			
	7 500 kg 2-axle rigid	N2	7 500-16	16 ±2	0° to 90° in 5° intervals
			7 500-32	32 ±2	
			7 500-48	48 ±3	
			7 500-64	64 ±3	

Table 2 Vehicle impact test criteria (continued)

Test vehicle classification		Test classification kg-km/h	Test speed km/h	Equivalent test speed (nominal) (mph)	Impact angle (°) (±2°)
Day cab vehicles (continued)	18 000 kg 2-axle rigid N3	7 500-16	16 ±2	(10)	0° to 90° in 5° intervals
		7 500-32	32 ±2	(20)	
		7 500-48	48 ±3	(30)	
		7 500-64	64 ±3	(40)	
		7 500-80	80 ±5	(50)	
	32 000 kg 4-axle rigid N3	30 000-16	16 ±2	(10)	0° to 90° in 5° intervals
		30 000-32	32 ±2	(20)	
		30 000-48	48 ±3	(30)	
		30 000-64	64 ±3	(40)	
		30 000-80	80 ±5	(50)	

NOTE 1 Vehicle speeds in km/h have been rounded to the nearest integer value.

NOTE 2 The N2 test vehicle is only acceptable for impact speeds up to and including 64 km/h. This is due to an inability to ensure that the ballast remains fixed to the load bed, without major modifications to the vehicle, at the moment of impact.

NOTE 3 See Figure 1 for vehicle classification illustrations.

5 Vehicle impact assessment

5.1 Performance requirements

When tested using the vehicle impact method the VSB system shall:

- bring to rest; or
- redirect an impacting vehicle on the approach side of the barrier.

Damage to, or movement of the VSB system 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 VSB system consists of bollards (active or passive VSB systems), each bollard shall meet the performance requirements individually.

Movement, lateral and rotational, of any foundation, and/or the bollard, shall be recorded and reported (see also Figure 6).

NOTE 2 If the VSB system 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 3. The test block should be offered to the opening formed in the VSB system 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 test report (see 5.2.6 and B.2).

If the manufacturer has specified more than one direction of impact, then the impact test shall be repeated for each specified direction using new test items.

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 VSB system under test to determine its impact resistance and subsequent classification.

Table 3 Vehicle impact method: Test vehicle specification



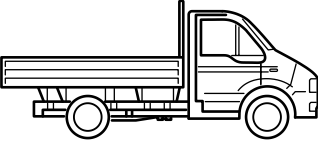
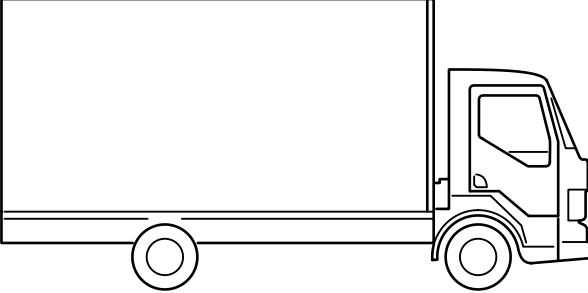
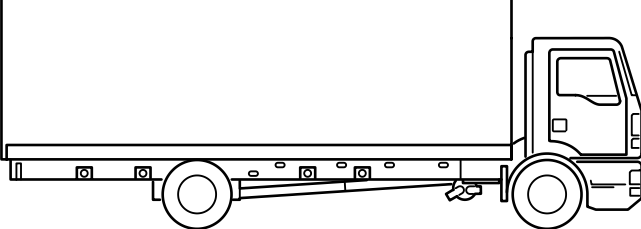
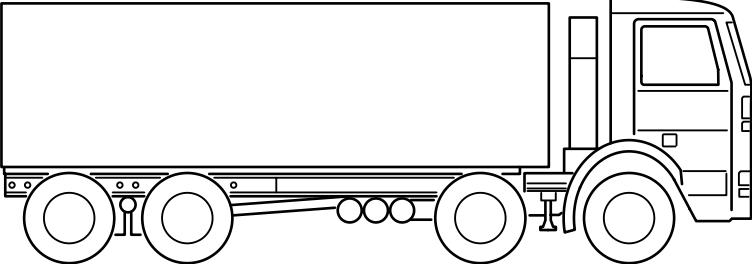
UN ECE international vehicle classification	M1	N1G	N1	N2	N3	N3
Type of test vehicle ^{A)}	Car	4x4 pick-up (crew cab design)	Day cab vehicles			
			3 500 kg flat bed (RWD) ^{B)}	7 500 kg 2-axle rigid	18 000 kg 2-axle rigid	32 000 kg 4-axle rigid (Tipper)
Nominal test vehicle mass (kg)	1 500	2 500	3 500	7 500	7 500	30 000
Minimum unladen mass (kg)	1 234	1 620	1 675	3 575	6 100	10 500
Maximum ballast (kg) ^{C)}	266	880	1 825	3 925	1 400	19 500
Inertial test vehicle mass (kg)	1 500	2 500	3 500	7 500	7 500	30 000
Tolerance (kg)	±50	±50	±100	±150	±150	±600
Overall vehicle length (mm)	4 500	4 900	6 200	7 612	9 557	10 240
Tolerance (mm)	±360	±320	±380	±1 522	±1 911	±500
Wheel base length (between extreme axles) (mm)	2 700	2 900	3 805	4 310	5 907	6 500
Tolerance (mm)	±540	±580	±710	±830	±1 250	±200

A) The types of vehicle are illustrated in Figure 1.

B) RWD = rear wheel drive.

C) The maximum ballast includes measuring and recording equipment, if requested. Such equipment should conform to the requirements of BS EN 1317-1:2010, Clause 6.

Figure 1 Vehicle classifications – Illustrations

Type of test vehicle	UN ECE International vehicle classification	Illustration
Car	M1	
4x4 pick up (crew cab design)	N1G	
Day cab vehicles	N1	
	N2	
	N3	
	N3	

5.2.2 Apparatus and measurement means

NOTE See also Clause 7 regarding documentation and information to be provided for testing purposes.

5.2.2.1 Test vehicle, a production model representative of the current traffic, having characteristics and dimensions within the vehicle specifications given in Table 3. The test vehicle shall be not more than 10 years old for vehicle types M1,

N1G, N1 and N2 and N3 (18 000 kg) and not more than 15 years for vehicle type N3 (32 000 kg).

The condition of the test vehicle shall be road worthy with respect to its:

- a) tyres;
- b) suspension;
- c) wheel alignment;
- d) bodywork;
- e) brakes; and
- f) chassis.

NOTE Attention is drawn to the Road Traffic Act 1991 [1] including its MOT requirements.

5.2.2.2 Winch, or alternative method of delivering the test vehicle to the test item 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 as close as possible to the test item, at which point it is released to travel freely.

5.2.2.3 Two means of speed measurement, capable of measuring the impact speed along the test vehicle's approach path at not more than 8 m before the impact point and with an accuracy in accordance with Table 2.

NOTE 1 A minimum of two independent methods of speed recording should be used. The determination of impact speed is an essential parameter.

NOTE 2 Suitable methods could include a timing gate, determination of winch cable speed, the use of pressure pads activated by the passage of the vehicle, or the analysis of overhead high-speed film records.

NOTE 3 For guidance on suitable instrumentation see BS AU 164/ISO 3784.

5.2.2.4 A method of measuring the approach angle, capable of measuring the test vehicle approach angle along the test vehicle approach path at not more than 8 m before the impact point and within a tolerance of $\pm 2^\circ$.

NOTE Suitable means could be the analysis of overhead high-speed film records.

5.2.2.5 A means of measuring distance, capable of measuring the maximum dispersion distance to an accuracy of 2%.

5.2.2.6 Photographic equipment, capable of clearly recording:

- a) the behaviour of the test item;
- b) the vehicle motion pre-impact from a minimum of 8 m before the point of impact and post-impact to a minimum of 25 m beyond the point of impact; and
- c) the distribution of major debris at a minimum of 25 m beyond the point of impact.

The period of recording shall commence from when the test vehicle is not less than 8 m before the impact point and shall conclude after the test vehicle and debris have come to rest.

High-speed camera systems shall be operated at a minimum of 200 frames per second and be capable of producing noise-free, correctly exposed²⁾ 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

²⁾ Results are considered to have been correctly exposed when the brightness range of the area of interest has been 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).

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 Figure 2 illustrates the indicative camera locations.

NOTE 2 Additional high-speed cameras are recommended, particularly where the test item has specific components that need to be assessed.

The minimum number of high-speed cameras and layout shall be as follows:

- 1) (see Figure 2, item a): one camera, sited at right angles to the path of the test vehicle and in a position to obtain a clear overall pictorial record of the impact and its consequences;
- 2) (see Figure 2, item b1): camera in-line with the test item and with an unobstructed view of its front face to record the test vehicle to test item interaction;
- 3) (see Figure 2, item b2): camera in-line with and facing the test vehicle approach direction;
- 4) (see Figure 2, item c): environmental conditions permitting and in agreement with the client, a minimum of two overhead cameras, located in such a way as to cover the vehicle motion from at least 5 m before the impact point to a distance adequate to record the performance of the test, the penetration of the test vehicle and the dispersion of the major debris up to a distance of 5 m from the rear face datum of the test item;

NOTE 3 Where environmental conditions (such as wind) prevail which could have an effect on the safety of personnel and equipment, it is advisable to carry out the test without use of the overhead high-speed cameras. Where overhead cameras are not used due to prevailing environmental conditions, other methods of measuring the approach angle include global positioning satellite (GPS) may be used.

- 5) (see Figure 2, item b3): one camera, to record the interaction of the test vehicle and the test item, location as agreed by the person carrying out the test and the client.

NOTE 4 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.

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

NOTE 5 Time references for camera recording can include, for example, distance marks at ground level, timing light, timing drum or timing marks made within the camera's field of view.

5.2.3 Pedestrian intruder access

If the VSB system is also intended to resist access by a pedestrian intruder, then following a vehicle impact, the barrier shall be assessed using the test block shown in Figure 3. The test block shall be offered to the opening formed in the VSB system by the impact to assess whether or not the full length of the block can pass axially through the opening. The result shall be recorded within the test report.

Figure 2 Indicative camera locations (plan view)

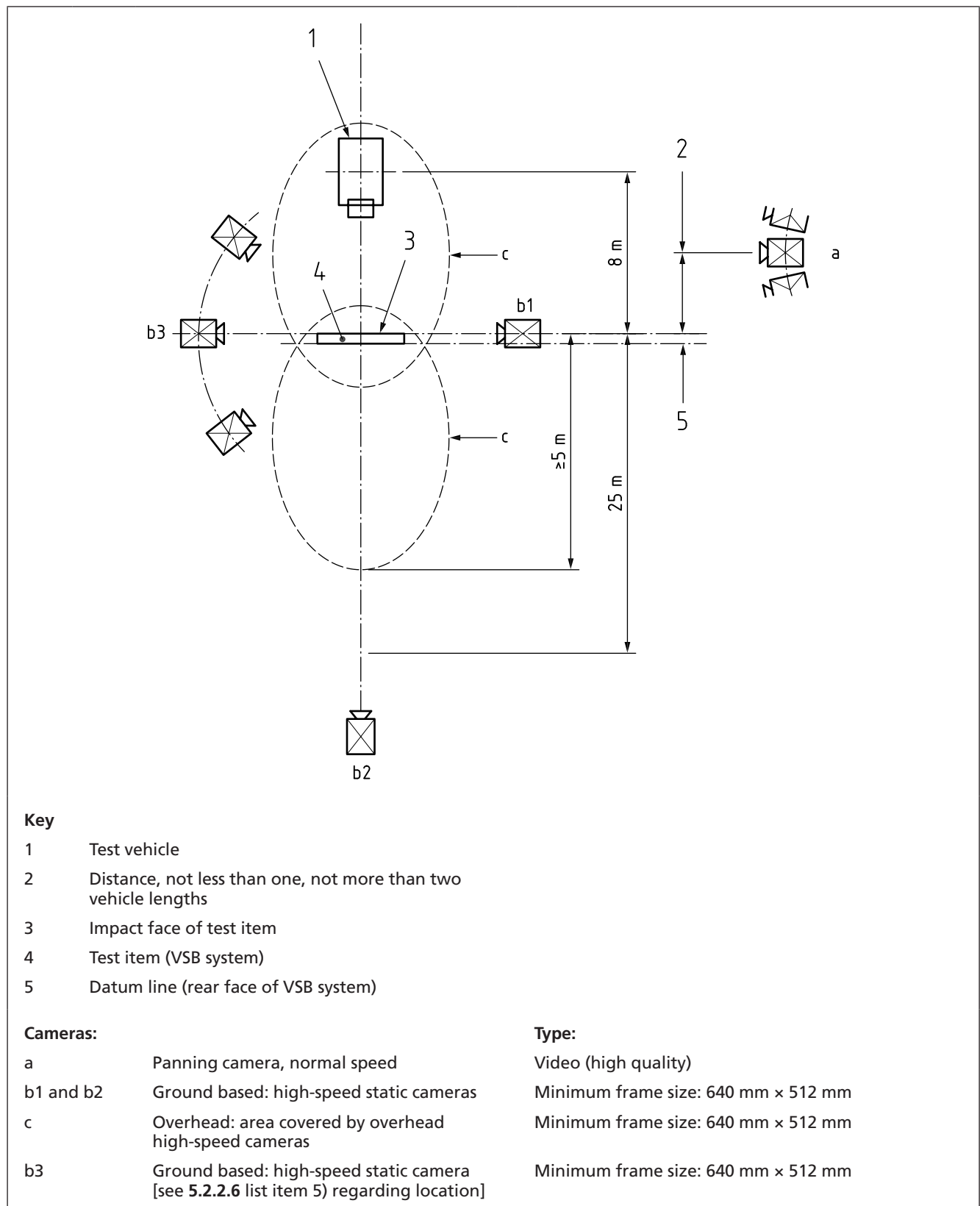
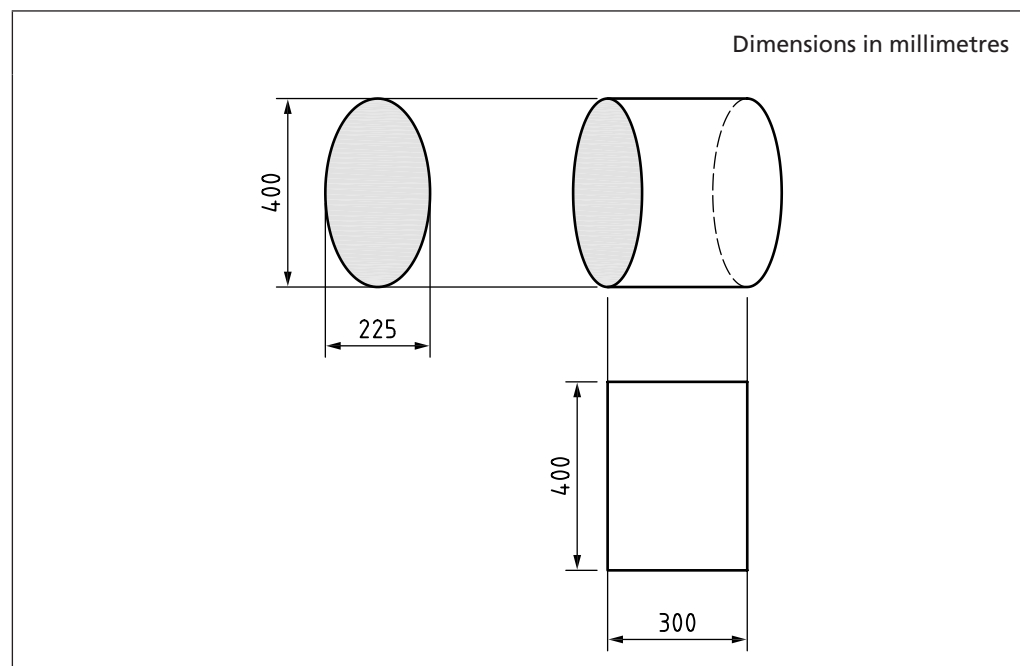


Figure 3 Pedestrian intruder test block



5.2.4 Preparations for testing

5.2.4.1 Test facility

5.2.4.1.1 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 to the required speed and controlled so that its approach to the test item is stable (negligible roll, pitch and yaw).

5.2.4.1.2 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.

5.2.4.1.3 To enable the test vehicle exit characteristics to be evaluated, the firm surface shall extend not less than 25 m beyond the rear face of the original test item.

5.2.4.1.4 Appropriate measures (e.g. dampening down and/or sweeping the test area) shall be taken in order to minimize dust or water spray generation from the test site and the test vehicle during the impact test so that photographic records are not obscured.

5.2.4.1.5 The test site shall be marked to indicate the rear face of the test item for the determination of the vehicle penetration and dispersion.

NOTE Suitable means of marking include spray painting lines, grids or target markers.

5.2.4.2 Test vehicle

5.2.4.2.1 The tyres shall be inflated to the vehicle/tyre manufacturer's recommended pressures.

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

5.2.4.2.3 The test vehicle shall not be restrained by external control of the steering or any other method (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 rear face of the original test item (unless the test vehicle poses a safety or operational risk).

5.2.4.2.4 All ballast shall be evenly distributed and fixed to the test vehicle in such a way as not to exceed the permissible axle loads for the vehicle.

5.2.4.2.5 Where the test vehicle is a car or a 4x4 pick-up, mark the intersection of the base of the windscreen and the "A" pillar with a quartered target marker.

NOTE Figure 4 illustrates test vehicles in the pre-impact condition and the post-impact condition.

5.2.4.2.6 When preparing a goods vehicle for test, the position of the leading edge of the load platform shall be marked with a quartered target marker. This position shall be duplicated with a clear mark on the chassis in case the load platform moves with relation to the chassis (see Figure 4).

NOTE 1 In the case of a goods vehicle, the equivalent longitudinal position (datum) should be marked on the vehicle chassis. Experience has shown that a second mark should be made towards the rear of the chassis and the distance from the datum recorded. This enables the position of the leading edge of the load bed to be determined more readily if the front of the vehicle/chassis is distorted due to the vehicle impact with the VSB system.

NOTE 2 Additional marks might be required in order to provide reference points for measurement purposes.

5.2.4.3 Test item

5.2.4.3.1 Photographs shall be taken to record the preparation and installation of the test item and its foundation.

5.2.4.3.2 For bollards, the test item shall have:

- a) a foundation constructed to drawings, as provided; or
- b) an integrated foundation.

NOTE Where the foundation to the test item is surrounded by natural soil or an infill material, compaction values should be recorded for the soil/backfill.

5.2.4.3.3 The test item shall be installed and located in its foundation or on the test site in accordance with the detailed drawings and installation instructions provided (see Clause 7).

5.2.4.3.4 The test item shall be installed to the specified height above ground in accordance with the detailed drawings and installation instructions provided.

5.2.4.3.5 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.

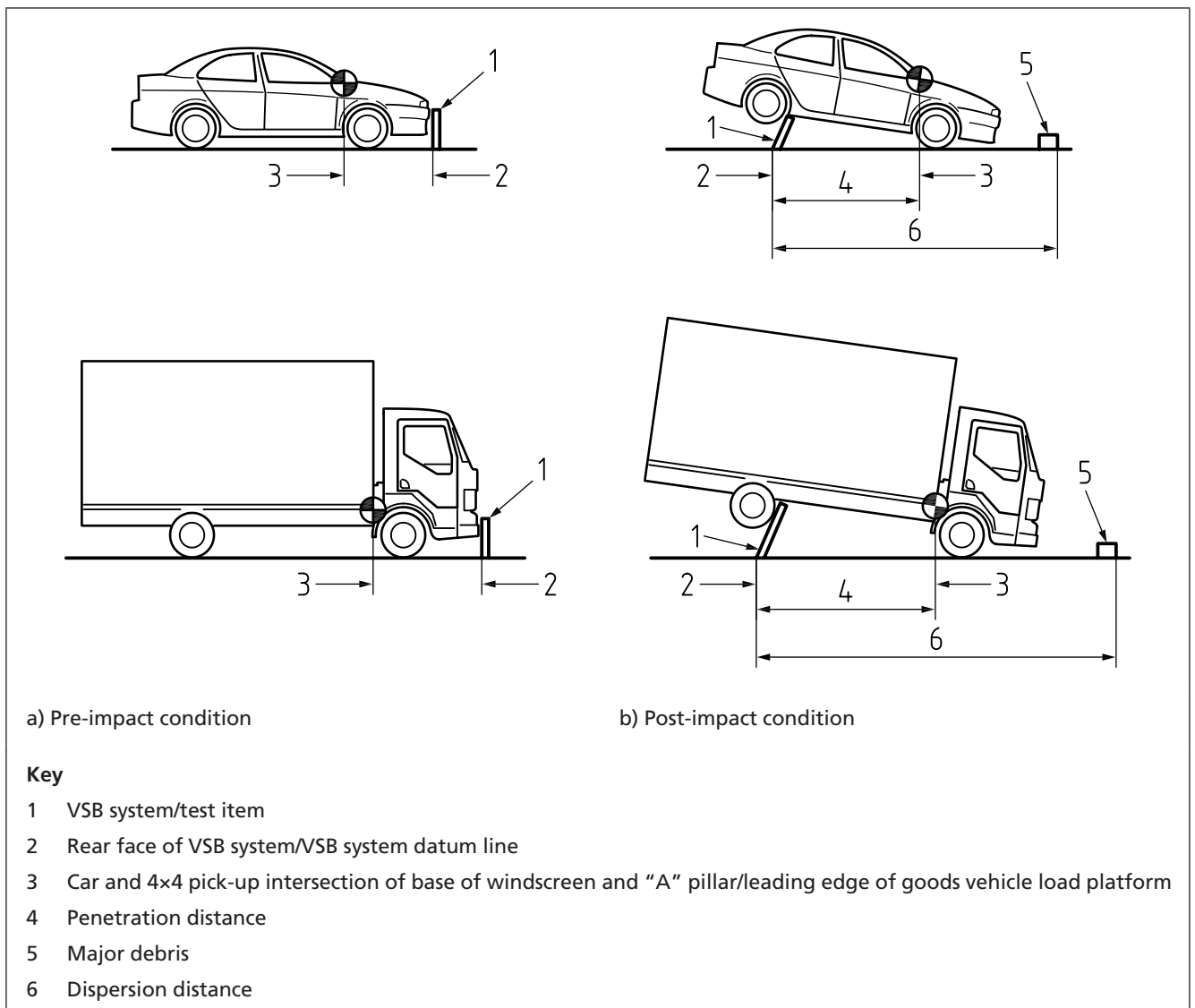
NOTE The alignment of the test item should be detailed in the installation instructions.

5.2.4.4 Occupant severity indices (optional)

If the determination of occupant severity indices is requested, measurement and recording equipment conforming to the requirements of BS EN 1317-1:2010, Clause 6, shall be installed.

NOTE Acceleration severity indices (ASI), Theoretical head impact velocity (THIV) are both examples of occupant severity indices.

Figure 4 Test vehicle impact condition



5.2.5 Test procedure

5.2.5.1 Pre-impact test data

The following pre-impact test data shall be recorded:

- a) where the VSB system is installed in or on cast concrete foundations, information covering the:
 - 1) date foundation was cast;
 - 2) results of test concrete cubes undertaken, in accordance with BS EN 12390-2 and tested at the intervals indicated in Table 4:

Table 4 Performance classification – Vehicle impact test

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

NOTE Samples are tested at intervals after the installation date (i.e. after the concrete has been poured) to determine the concrete strength, for example:

- i) if testing ≥ 28 days after the concrete is poured, samples are tested on day 7, day 14, day 28 (to allow the curing rate to be monitored), and on the day of the test;
- ii) if the test day is on day 11 after the concrete has been poured, samples are taken on day 7 and day 11 (the day of the test);
- iii) if the test day is on day 5 after the concrete has been poured, a sample is only taken on day 5 (the day of the test).

- b) height, angle of inclination (bollards), location within foundation and installation depth;
 - c) mass of the test vehicle;
 - d) vehicle dimensions;
 - e) location of the centre of gravity of the test vehicle in the test condition, including added ballast, for test vehicles having a test vehicle mass of 1 500 kg and 2 500 kg (see Table 3);
- NOTE 1* Attention is drawn to BS ISO 10392.
- f) location of the centre of gravity of the added ballast for test vehicles having a test vehicle mass of 3 500 kg, 7 500 kg and 30 000 kg (see Table 3);
 - g) still photographs taken at 90° and 45° to each face of the following, as a minimum:
 - 1) construction of foundation and installation of test item;
 - 2) test item;
 - 3) test vehicle;
 - 4) test vehicle at impact point, including an overhead view, where practicable;
 - 5) interior of the test vehicle;
 - h) intended test vehicle impact point (see 5.2.5.2);
 - i) height of contact between the test vehicle and the intended impact point on test item; and
 - j) for an active VSB system, the operating cycle (e.g. rising/dropping/sliding/swinging) of the test item.

NOTE 2 Where applicable, the ground conditions during testing may be included in the test report, if requested.

NOTE 3 Other standards regarding concrete, cement and mortar include: BS 4449, BS 4483, BS EN 934-3, BS 8500-1, BS 8500-2, BS 8666, BS EN 197-1, BS EN 934-2, BS EN 1008, BS EN 12620 and BS EN 13139. See the bibliography for further information.

5.2.5.2 Impact

Subject the test item to a single vehicle impact applied at a point in the client's defined plane of impact to the selected test impact criteria.

5.2.5.3 Impact data

Record the following impact data:

- a) impact speed (km/h), measured using speed measurement equipment (see 5.2.2.3) along the test vehicle approach path no further than 8 m before the impact point;
- b) test vehicle approach angle, measured using approach angle measurement equipment (see 5.2.2.4) along the test vehicle approach path no further than 8 m before the impact point (measured in degrees);
NOTE For guided test vehicles, this may be a static measurement made in advance of the actual test.
- c) actual test vehicle impact point (see 5.2.5.2), relative to the defined point of impact;
- d) photographically (see 5.2.2.6): the behaviour of the test item, the test vehicle motion pre-impact and post-impact up to 25 m beyond the point of impact as well as the distribution of major debris;
- e) height of contact between the vehicle (mid height of bumper) and barrier;
- f) vehicle acceleration data, if requested, for the evaluation of occupant severity indices.

5.2.5.4 Post-impact data

Record the following post-test data:

- a) vehicle penetration (static and dynamic);
- b) dispersion maximum distance of major debris and/or any VSB system components using distance measurement equipment (see 5.2.2.5);
- c) damage to the VSB system, foundation and test vehicle;
- d) movement of the test item/foundation (e.g. linear and/or rotational) and its displacement;
- e) still photographs taken at 90° and 45° to each face of the following, as a minimum:
 - 1) foundation and test item;
 - 2) test item;
 - 3) test vehicle;
 - 4) interior of the test vehicle;
- f) for an active VSB system, the operating cycle (e.g. rising/dropping/sliding/swinging) of the test item with the test vehicle in place;
- g) for an active VSB system, the operating cycle (e.g. rising/dropping/sliding/swinging) of the test item with the test vehicle removed (as necessary);
- h) for bollards, irregularities in the gap between the test item and its foundation;
- i) for bollards, crush/distortion of section;
- j) the movement of the test item foundation (e.g. linear and/or rotational) (as shown in Figure 5);
- k) with the test vehicle removed, determine the damage and deformation of the test item. For a bollard, also record the angle of inclination from a line normal to the surface of the test item foundation as shown in Figure 6;
- l) if requested, evaluate the occupant severity indices.

NOTE For the purposes of recording penetration and dispersion, examples of the datum line (rear-face) of the VSB system are shown in Figure 5.

Figure 5 Foundation movement criteria for VSB systems (excluding bollards) to be recorded

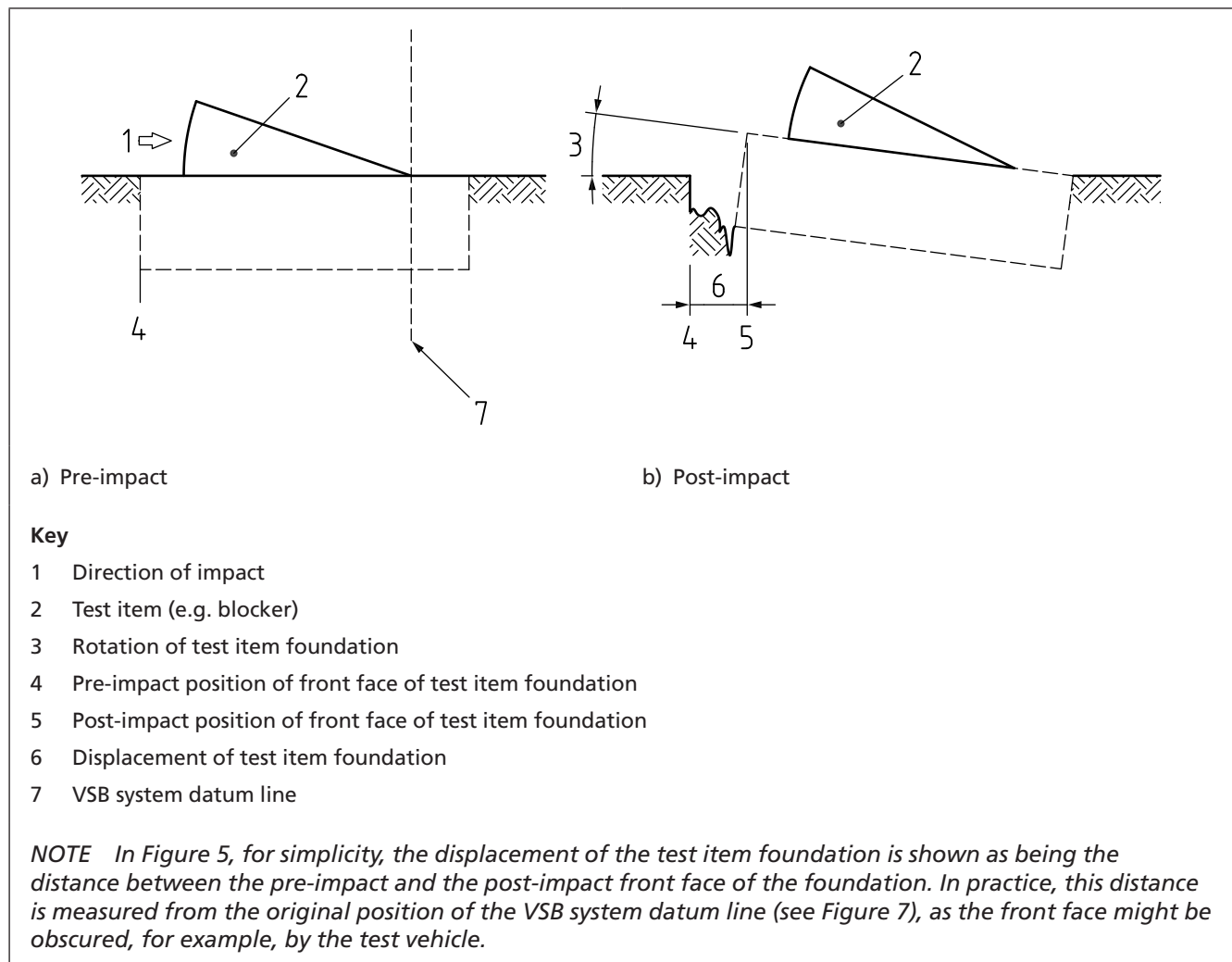


Figure 6 Foundation movement and bollard criteria to be recorded

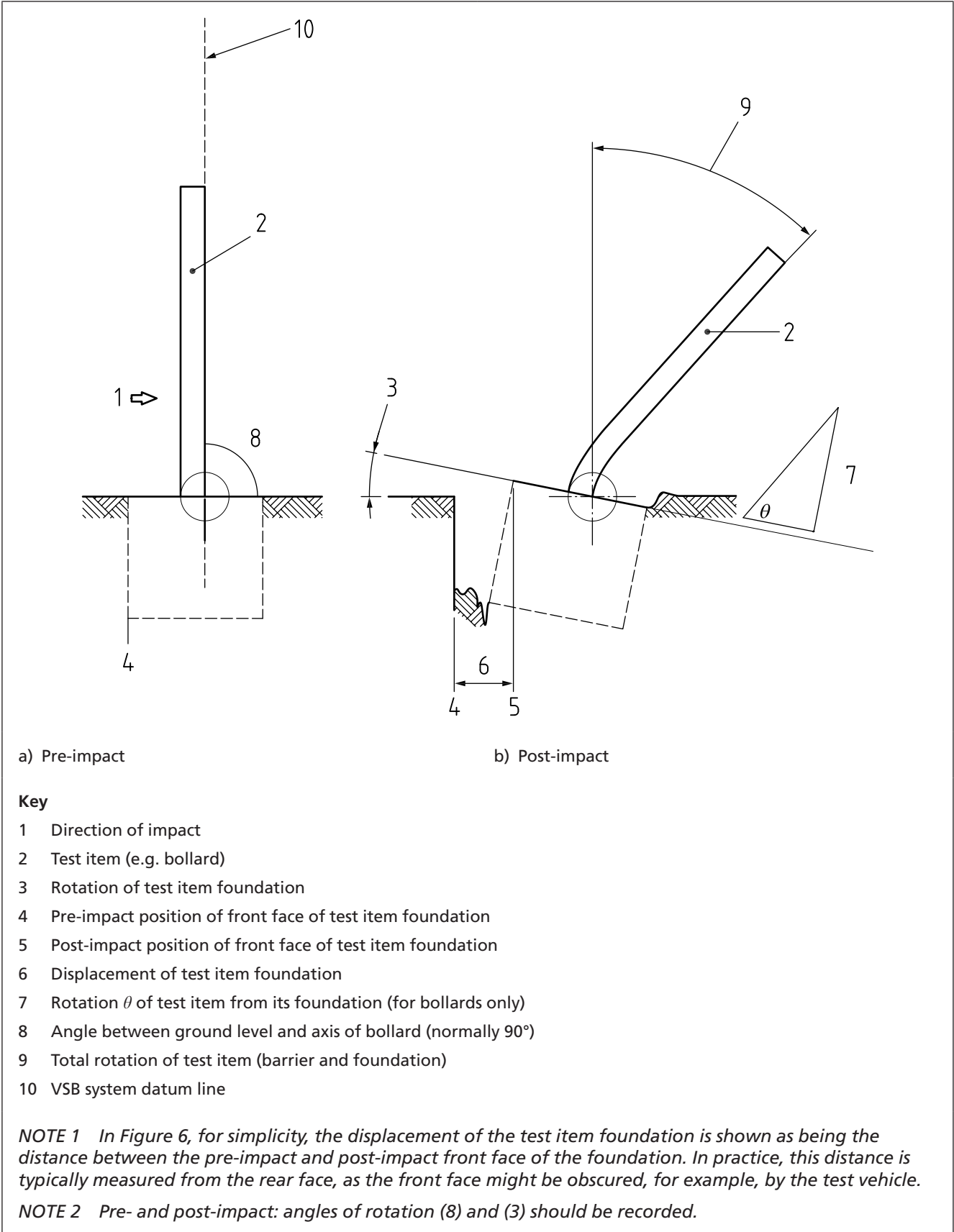
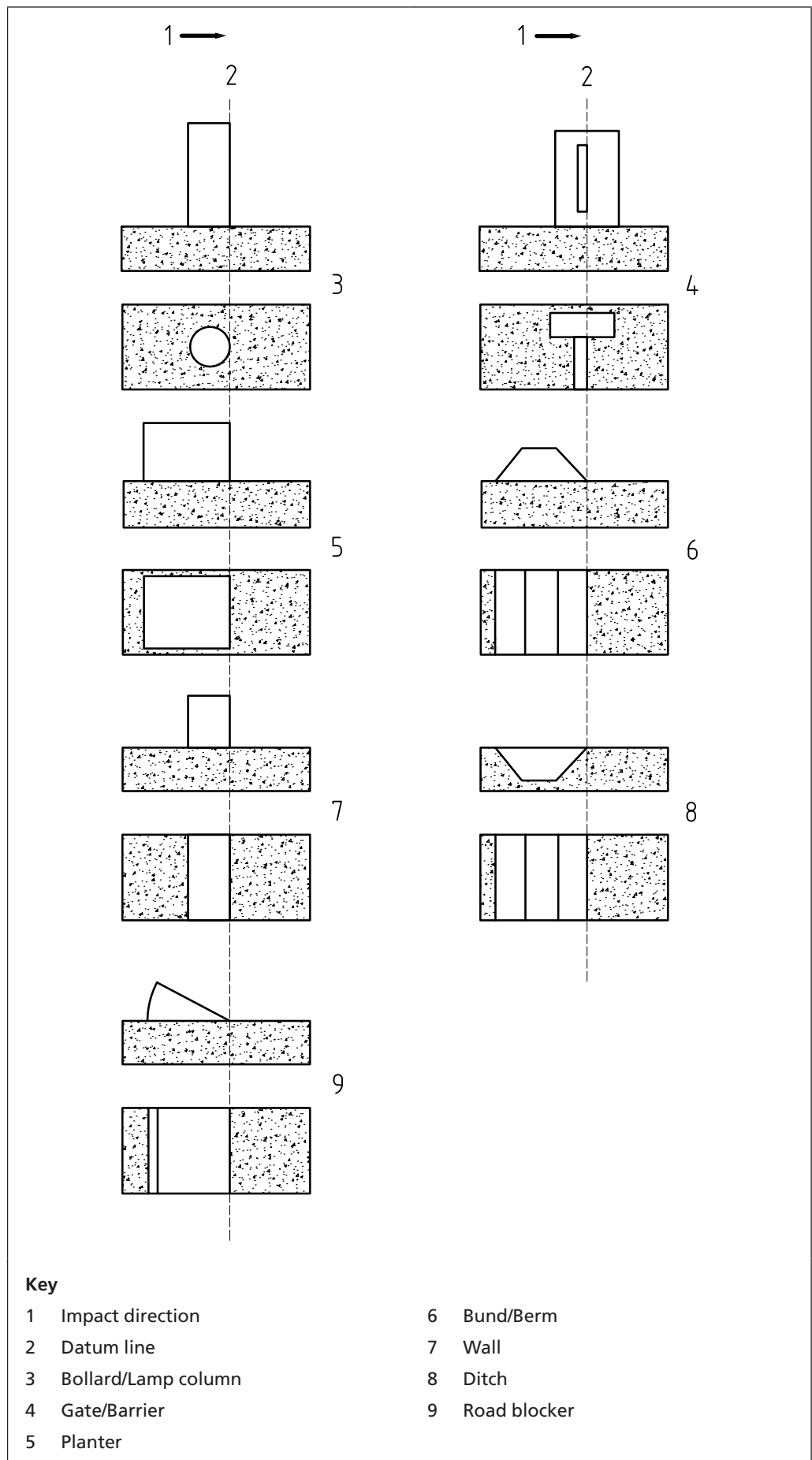


Figure 7 VSB system datum line



5.2.5.5 Post-impact vehicle encroachment data

With reference to a vertical plane from the base of the test item barrier in its pre-impact position, measure the maximum horizontal distortion/displacement at 100 mm intervals taken from finished ground level to 600 mm above finished ground level.

NOTE A gap of 1.2 m within the line of the VSB system(s) measured at 600 mm above finished ground level is deemed to be encroachable by a subsequent vehicle.

5.2.5.6 Post-impact person access data

Where the test item is also intended to resist access by a pedestrian intruder, record the result in accordance with 5.2.3.

5.2.5.7 Further impact tests

Where additional impact angles and/or impact speeds are to be assessed, repeat the impact test (5.2.5) for each specified impact angle [see Table 2] and/or impact speed.

A new test item shall be used for each impact test, unless the test item is determined to be fit for further evaluation.

NOTE The impact points to represent the worst-case scenario and whether the test item is fit for further evaluation should be assessed.

5.2.6 Test report

A test report shall be prepared for each impact.

NOTE See Annex B for test report recommendations.

5.2.7 Modifications to tested and classified products

If the tested product specification is modified in any way, it shall be reassessed according to Annex C.

6 Design method

NOTE The design method is used for variations or modifications in design to a previously classified VSB. Full-scale test data is used for interpolation and finite element analysis (FEA) may form part of this method. Further information on FEA and computer modelling validation can be found in PD CEN/TR 16303-4.

6.1 Performance classification

The VSB system assessed in accordance with the design method shall be classified for performance in accordance with Table 5.

Table 5 Design method: Performance classification

1 VSB system type ^{A)}	2 D	3 Test inertial mass kg	4 Impact speed km/h	5 Impact angle °	6 Impact energy kJ
Blocker	D	7 500	48	45	472

EXAMPLE PAS 68:2013 Blocker D/7 500(N2)/48/45/472:

- 1) Blocker
- 2) Design method
- 3) Delivered by a 7 500 kg (N2) vehicle
- 4) Impact speed: 48 km/h
- 5) Impact angle: 45° to the front face of the blocker
- 6) Theoretically capable of withstanding an impact of 472 kJ (taking into account angle of impact)

A) See Annex A.

6.2 Design criteria

The design impact energy shall be selected from the values given in Table 6 which is derived from vehicle impact criteria.

NOTE This also indicates the impact speed/vehicle mass combinations, which can theoretically be withstood by the VSB system.

Table 6 Design method: Impact energy values (kJ)

UNECE vehicle classification	M1	N1G	N1	N2	N3	N3
Test vehicle impact speed km/h	Test vehicle mass kg					
	1 500	2 500	3 500	7 500	7 500	30 000
16	15	25	35	74	74	296
32	59	99	138	296	296	1 185
48	133	222	311	667	667	2 667
64	237	395	553	1 185	1 185	4 741
80	370	617	864	1 852	1 852	7 407
96	533	889	1 244			
112	726	1 210				

NOTE 1 Vehicle speeds have been rounded to the nearest integer value.

NOTE 2 When designing VSB systems using Table 6, energy values are not transferable between vehicle classifications and selected impact speeds should be either adjacent to each other or not separated by more than one speed.

6.3 Design procedure

Full-scale test impact data shall be used for interpolation in designing a VSB system.

NOTE FEA procedures, validated by full-scale impact test data, may also be used.

6.4 Design data

6.4.1 The calculations demonstrating that the VSB system theoretically meets its claimed performance class shall be provided.

6.4.2 The following minimum information about the VSB system shall be provided:

- a) overall product dimensions;
- b) component thickness including wall thickness of hollow sections;
- c) specifications for all materials used (including fill materials used on the product); and
- d) design of foundation.

7 Documentation

For impact tests, the following information and documentation shall be provided for testing purposes:

- a) contact details of the client undertaking the test;
- b) VSB system manufacturer contact details, if not the client;
- c) whether the VSB system is a prototype or is in production;
- d) model designation of the VSB system;
- e) the test vehicle specification and impact criteria against which the VSB system is to be tested;
- f) which face of the VSB system is designed to resist impact;
- g) general arrangement drawings, installation drawings and installation instructions;
- h) component drawings and foundation designs with dimensions, tolerances and all material specifications and finishes;
- i) factory sub-assembly drawings;
- j) parts list;
- k) components – certificate or material specification, where compliance stated;
- l) maintenance and repair instructions (if applicable);
- m) operating manual (if applicable);
- n) any other relevant information (e.g. information for disposal and/or recycling of the VSB system, details of toxic or dangerous materials in the product and safety issues).

NOTE 1 Attention is drawn to the Data Protection Act 1998 [2].

Where required, the document shall be marked “commercial in confidence” and shall be retained, handled and stored by the test house accordingly.

NOTE 2 For the design method, see Clause 6.

8 Test preparation

NOTE Users of this PAS are advised to consider the desirability of third-party testing of product conformity with this PAS. Appropriate conformity attestation arrangements are described in BS EN ISO/IEC 17025. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association. BS EN ISO/IEC 17025 also provides testing procedures [handling of test item(s), event record requirements and presentation of the test report].

8.1 Conformity between test item(s) and documentation

The documentation provided for testing purposes shall be checked and compared against the test item and confirmed to be accurate (see Clause 7). Any discrepancies shall be recorded and reported to the manufacturer prior to the test.

The manufacturer shall resolve the discrepancy through the provision of corrected drawings and/or test item before proceeding with testing.

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

8.2 Test item selection

Prior to testing, the selected test item shall be examined and confirmed to have dimensional conformity to the design drawings.

NOTE See also 8.1.

8.3 Impact point

For impact tests, the designated impact point between the vertical centre-lines of the impact faces of the test vehicle and the VSB system shall be recorded and be achieved within ± 100 mm.

For the vehicle impact test, quartered targets shall be applied to the centre-lines of both the test vehicle and the VSB system so as to be visible from the downstream camera (see 5.2.2.6 and Figure 2).

8.4 Test system operation

During pre- and post-impact, the operation of an active VSB system (e.g. rising, falling, sliding or swinging) shall be demonstrated and the functionality of the system shall be recorded [see 5.2.5.1 and 5.2.5.4].

Annex A
(normative)

VSB system classification types

A.1 General

VSB systems shall be classified according to the following criteria and in accordance with A.2 to A.5:

- foundation type;
- activity;
- operation (active VSB systems only); and
- VSB system type.

NOTE Further standards regarding VSB systems include: BS EN 1317-2, BS EN 1317-3, BS EN 12899-2 and DD ENV 1317-4. See the bibliography for further information.

A.2 Foundation

The VSB system foundation shall be classified according to Table A.1.

Table A.5 Foundation classification

Classification	Description
A	Freestanding; having no ground fixings
Ap	Surface mounted but also pinned or bolted to the ground
B	Depth ≤ 0.5 m below ground level
C	Depth > 0.5 m below ground level

A.3 Activity

The VSB system activity shall be classified according to Table A.2.

Table A.6 VSB system activity

Classification	Description
Active VSB system	VSB system that can be opened to enable passage to vehicles
Passive VSB system	Static VSB system having no moving parts

A.4 Operation (applicable to active VSB systems only)

The VSB system operation shall be classified according to Table A.3.

Table A.7 VSB system operation (active VSB systems only)

Classification	Description
Retractable	Pivoting in the vertical plane
Rising	Vertical or rotating movement in the vertical plane
Sliding	Horizontal movement in the vertical plane
Swinging	Pivoting in the horizontal plane

A.5 VSB system type

The VSB system type shall be classified according to Table A.4.

Table A.8 VSB system type

Classification	Description
VSB system	Structure preventing vehicle passage. Can be permeable (e.g. bollard) or continuous (e.g. wall). Can be active or passive
Ditch	Profiled excavation
Berm	Profiled mound of soil
Fence	Series of linked posts
Wall	Continuous vertical structure
Planter	Passive unit containing plant or trees
Bollard	Passive or active post (typically rising vertically)
Blocker	Active vehicle access control system (typically retracting into the ground)
Gate	Active vehicle access control system (typically rising, swinging or sliding)
Door	Active vehicle access control system in a wall

NOTE Wherever practicable, the detailed dimensions of the different VSB system types should be given as follows:

- *Blocker* – height, width (of front face);
- *Bollard* – height, diameter;
- *Door* – aperture height, aperture width;
- *Fence* – height;
- *Gate* – upper and lower height of arm or boom, aperture width;
- *Planter* – height, width (of front face), depth (front to rear face);
- *Wall* – height, depth (front to rear face).

Annex B
(informative)**Proforma test report****B.1 Impact test report**

The following should be reported when an impact test report is prepared for PAS 68:

- a) product name;
- b) test number;
- c) test date;
- d) report number and a version number, where applicable;
- e) type of test, i.e. mass, speed, angle;
- f) date of report issued;
- g) author and technical reviewer, including appropriate approval signatures.

B.2 Contents of report

The following should be contained in an impact test report:

- a) introduction;
- b) executive summary;
- c) test item description;
- d) impact results;
- e) system damage;
- f) test vehicle damage;
- g) conclusions and any associated notes;
- h) ground level views from high speed video;
- i) overhead views from high speed video;
- j) post-impact test item and test vehicle damage images;
- k) general comments;
- l) disclaimer(s);
- m) data summary and analysis, where applicable;
- n) occupant severity indices, where applicable;
- o) concrete cube strength tests, where applicable.

Annex C (normative) Prototypes

The implications of any modifications to an assessed VSB system shall be evaluated and declared in respect of its effect on the performance of the VSB system. If a prototype VSB system meets the requirements of this PAS and subsequently an application is made for its formal approval, then the following conditions shall apply.

- a) If there are no changes to the original product or its associated design drawings, then the VSB system may be approved.
- b) If there are any modifications, the manufacturer shall describe them in respect of drawings and specifications used to define the VSB system in the original assessment. The procedure for the assessment of modified products shall be in accordance with Table C.1.

Table C.1 Assessment of modified VSB systems

Category	Change	Description	Action
A	Slight	Modifications requiring no mechanical changes to the VSB system or to its foundations or installation, e.g. changes to the finish of components, such as painting or galvanizing.	Changes shall be described on the drawings and a set of revised drawings with a unique identifier supplied to the party responsible for testing. A statement to the effect that "the modification will have no effect on the tested performance", shall be supplied by the VSB system manufacturer and this together with the drawings shall be recorded and retained by the party responsible for testing.
B	Moderate	Modifications to one or more components where their effects on the performance of the system can be determined by static or dynamic analysis, e.g. FEA procedures or physical testing, change of component material specification.	Component analysis or test shall be undertaken. Results of the analysis or test shall be reported, together with a copy of the original pre-modification results. A uniquely identified revised set of documents (including drawings) shall be supplied to the party responsible for testing for recording and retention.
C	Significant	Modifications in excess of A or B	A re-assessment of the VSB system in accordance with PAS 68 by impact test. All documentation shall clearly identify all modifications to the VSB system and its code, as amended, e.g. Version 2 (see Clause 7).

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- BS 4449, *Steel for the reinforcement of concrete – Weldable reinforcing steel – Bar, coil and decoiled product – Specification*
- BS 4483, *Steel fabric for the reinforcement of concrete – Specification*
- BS 8500-1:2006+A1:2012, *Concrete – Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier*
- BS 8500-2:2006+A1:2012, *Concrete – Complementary British Standard to BS EN 206-1 – Part 2: Specification for constituent materials and concrete*
- BS 8666, *Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete – Specification*
- BS AU 164/ISO 3784, *Specification for measurement of impact velocity in collision tests on road vehicles*
- BS EN 197-1, *Cement – Part 1: Composition, specifications and conformity criteria for common cements*
- BS EN 934-2, *Admixtures for concrete, mortar and grout – Part 2: Concrete admixtures – Definitions, requirements, conformity, marking and labelling*
- BS EN 934-3, *Admixtures for concrete, mortar and grout – Admixtures for masonry mortar – Part 3: Definitions, requirements, conformity, marking and labelling*
- BS EN 1008, *Mixing water for concrete – Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*
- BS EN 1317-2, *Road restraint systems – Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets*
- BS EN 1317-3, *Road restraint systems – Part 3: Performance classes, impact test acceptance criteria and test methods for crash cushions*
- BS EN 12620, *Aggregates for concrete*
- BS EN 13139, *Aggregates for mortar*
- BS EN 12899-2, *Fixed, vertical road traffic signs – Part 2: Transilluminated traffic bollards (TTB)*
- BS EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*
- BS ISO 6813, *Road vehicles – Collision classification – Terminology*
- BS ISO 10392, *Road vehicles – Determination of centre of gravity*
- CWA 16221, *Vehicle security barriers – Performance requirements, test methods and guidance on application*
- DD ENV 1317-4, *Road restraint systems – Part 4: Performance classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers*
- PAS 69, *Guidance for the selection, installation and use of vehicle security barrier systems*
- PD CEN/TR 16303-4, *Road restraint systems – Guidelines for computational mechanics of crash testing against vehicle restraint system – Part 4: Validation procedures*

Other publications

- [1] UNITED KINGDOM. The Road Traffic Act 1991. London: The Stationery Office.
- [2] UNITED KINGDOM. The Data Protection Act 1998. London: The Stationery Office.

Further reading

BS 4-1, *Structural steel sections – Part 1: Specification for hot rolled sections*

BS 5606, *Guide to accuracy in building*

BS 7973:1, *Spacers and chairs for steel reinforcement and their specification – Part 1: Product performance requirements*

BS EN 40 (all parts), *Lighting columns*

BS EN 1090-2, *Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures*

BS EN 1993-1-2, *Eurocode 3 – Design of steel structures – Part 1-2: General rules – Structural fire design*

BS EN 10025-1, *Hot rolled products of structural steels – Part 1: General technical delivery conditions*

BS EN 12899-1, *Fixed, vertical road traffic signs – Part 1: Fixed signs*

BS EN ISO 8503 (all parts), *Preparation of steel substrates before application of paints and related products – Surface roughness characteristics of blast-cleaned steel substrates*

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