STONE
Security Engineering

Anti-Ram Vehicle Barriers: Rating Systems

A Stone Security Engineering White Paper

Updated 2018

Hollice Stone, PE and Richard Galli, PE

Summary
To date, the Department of State (DoS), ASTM, the British Standards Institution (BSI), and the International Standards Organization (ISO) have developed rating systems and testing standards for Anti-Ram Vehicle Security Barrier (VSB) Systems. Rating systems are defined by some combination of the size, velocity and angle of approach of the design vehicle (which can be translated into Kinetic Energy) and the allowable penetration distance. In addition to these ratings standards/systems many agencies have anti-ram requirements that reference these standards. For the US, these include the Department of Defense, the General Services Administration / Interagency Security Committee, the Federal Emergency Management Agency, the Department of Veteran Affairs, Customs and Border Patrol, and the New York Police Department.

Prior to specifying anti-ram performance requirements, the design team should understand the different rating systems and the proof of performance methods that may be required by the specification.

US Department of State Ratings and Testing Requirements
The original DoS rating system and test standard was published in SD-STD-02.01 *Certification Standard*: *Test Method for Vehicle Crash Testing of Perimeter Barriers and Gates*, dated April 1985. This was subsequently revised in SD-STD-02.01, Revision A *Certification Standard: Test Method for Vehicle Crash Testing of Perimeter Barriers and Gates*, dated March 2003. These documents provide "specified levels of vehicle impact resistance" and details of the testing requirements to gain DoS certification. The standard vehicle mass for the current DoS rating system is a medium duty truck with a gross vehicle mass of 6,800 kg (15,000 lb). Impact Condition Designations are shown in the table below.

DoS Impact Conditions

Nominal Impact Speed	Designation
80 kph (50 mph	K12
65 kph (40 mph)	K8
50 kph (30 mph)	K4

From a rating system perspective, the primary change from the 1985 to the 2003 document was the removal of different allowable penetration distances. The 1985 document utilized "L" ratings to describe the amount of penetration that occurred from the medium duty truck travelling at the nominal impact speed. The 2003 document removed the different penetration distances and now requires that all barriers receiving a DoS certification allow no more than 1 m (3.33 ft) penetration beyond the inside perimeter of the barrier.

The penetration distance is measured based on reference points on both the vehicle and the barrier system. The reference points in the 2003 standard are at the leading edge of the test vehicle's cargo bed and at the inside face (e.g. non-impact side) of the barrier. Distances are based on the dynamic penetration, that is the maximum penetration distance as opposed to the final penetration distance.

The following table provides the previous penetration rating system used by DoS. This is provided as many of the early proprietary systems were certified using the "L" penetration rating system. While the tested systems with penetration distances greater than 1 m (3.3ft) no longer meet DoS requirements, they may be correlated with the new ASTM Rating System (described below) which may be useful in DoD projects which have more flexibility as to the requirements of the vehicle barrier systems.

DoS Penetration Ratings*

Designation	Penetration
L 3.0	<=1m (3.3 ft)
L 2.0	<= 6m (20 ft)
L 1.0	<= 15m (50 ft)

* no longer used for DoS projects

ASTM Ratings and Requirements

ASTM has developed a *Standard Test Method for Vehicle Crash Testing of Vehicle Security Barriers*, Standard F-2656-18a. This standard builds on the DoS standard and expands it for a wider range of project requirements (i.e. different vehicle sizes, additional velocities, and allowable penetration distances). The following tables show a summary of Impact Condition Designations and Penetration Ratings.

ASTM Impact Condition Designation

Test Vehicle / Mass*	Nominal Impact Velocity	Condition Designation*
SC: 1,100 kg (2,430 lbm)	50 kph (30 mph)	SC30
	65 kph (40 mph)	SC40
	80 kph (50 mph)	SC50
	100 kph (60 mph)	SC60
FS: 2100 kg (4630 lbm)	50 kph (30 mph)	FS30
	65 kph (40 mph)	FS40
	80 kph (50 mph)	FS50
	100 kph (60 mph)	FS60
PU: 2,300 kg** (5,070 lbm)	50 kph (30 mph)	PU30
	65 kph (40 mph)	PU40
	80 kph (50 mph)	PU50
	100 kph (60 mph)	PU60
M: 6,800 kg (15,000 lbm)	50 kph (30 mph)	M30
	65 kph (40 mph)	M40
	80 kph (50 mph)	M50
C7: 7,200 kg (15,873 lbm)	50 kph (30 mph)	C730
	65 kph (40 mph)	C740
	80 kph (50 mph)	C750
H:29,500 kg (65,000 lbm)	50 kph (30 mph)	H30
	65 kph (40 mph)	H40
	80 kph (50 mph)	H50

* The prefix in the Condition Designator refers to the vehicle type. SC = Small Car, FS= Full-size Sedan, PU = Pick-up M = Standard Test Truck, C7= Class 7 Cabover, and H = Heavy Goods Vehicle.
** There is a slight discrepancy within the ASTM standard on the PU vehicle mass. The tabulated rating parameters list the test mass as 2300 kg (5070 lbm) while the detailed vehicle description lists the test mass as 2270 kg (5000 lbm). For all other vehicle types the values in the tabulated parameters match the detailed descriptions.

ASTM Penetration Ratings

Designation	Penetration
P1	<= 1m (3.3 ft)
P2	1.01m to 7m (3.3 ft to 23.1 ft)
P3	7.01m to 30m (23.1ft to 98.4ft)

The current DoS ratings of K12, K8 and K4 can be described in terms of the ASTM rating system as follows:

- K12 = M50-P1
- K8 = M40-P1
- K4 = M30-P1

Penetration distance measurements in the ASTM document are the same as in the DoS 2003 document (i.e. dynamic penetration as measured from set reference points on the vehicle and the barrier).

British Standards Institution (BSI)

The prevalent anti-ram testing standard in the United Kingdom is the BSI Publicly Available Specification: PAS 68/69:2013, *Impact Test Specifications for Vehicle Security Barrier Systems* and *Guidance for the Selection, Installation and Use of Vehicle Security Barrier Systems*. This standard is based on similar premises as the DoS and ASTM documents. The PAS allows testing by vehicle impact. The standard also allows limited analysis (Design) for interpolating test results between two or more test cases or use of Finite Element Analysis procedures (when validated by full scale testing) to extrapolate test conditions. The PAS 68 provides two classification systems based on the method of classification (i.e. vehicle impact or analysis).

Vehicle Impact: seven-part classification system.

- Rating Standard/ Edition (PAS 68:2013) and Barrier Type
- Test Method (V)
- Test Vehicle Mass (kg) and Classification
- Test Vehicle Speed Classification (kph)
- Impact Angle (degrees)
- Vehicle Penetration (m)
- Dispersion of Major Debris (m)

An example rating would be PAS 68:2013 / Fence / V / 1500 (M1) / 48 / 90 / 1.0 / 1.5 would be a fence system rated using the vehicle impact test capable of withstanding an impact by a 1500 kg car at an impact speed of 48 kph and impact angle of 90 degrees where the penetration was 1.0 m and where major debris landed no more than 1.5 m beyond the reference point.

Design Method: six-part classification systems.

- Rating Standard / Edition (PAS 68:2013) and Barrier Type
- Design Method (D)
- Test Vehicle Mass (kg) and Classification
- Test Vehicle Speed Classification (kph)
- Impact Angle (degrees)
- Perpendicular Impact Energy (kJ)
- Dispersion of Major Debris (m)

International Standards Organization (ISO)

An additional anti-ram testing standard is ISO International Workshop Agreement (IWA) 14-1/2, *Vehicle Security Barriers – Part 1: Performance Requirement, Vehicle Impact Test Method and Performance Rating* and *Vehicle Security Barriers – Part 2: Application*. This standard is structured similarly to the PAS document and like the PAS document is based on similar premises as the DoS and ASTM documents. The IWA 14-1 allows testing by vehicle impact. The standard also allows for more limited analysis (Design) than the PAS, limited to interpolating test results between two or more full scale tests conducted using the same class of vehicle with one relevant dimension changed. The IWA

provides two classification systems based on the method of classification (i.e. vehicle impact or analysis).

Vehicle Impact: seven-part classification system.

- Rating Standard/ Edition (IWA 14-1:2013) and Barrier Type
- Test Method (V)
- Test Vehicle Mass (kg) and Classification
- Test Vehicle Speed Classification (kph)
- Impact Angle (degrees)
- Vehicle Penetration (m)
- Dispersion of Major Debris (m)

Design Method: six-part classification system.

- Rating Standard/ Edition (IWA 14-2:2013) and Barrier Type
- Design Method (D)
- Test Vehicle Mass (kg) and Classification
- Test Vehicle Speed Classification (kph)
- Impact Angle (degrees)
- Vehicle Penetration- the greater of the two tests being interpolated (m)

Vehicle Designation Comparison

The vehicle mass categories of the ASTM standards, the PAS 68, and IWA 14 can roughly be compared as shown in the following table, with the PAS 68 vehicle masses larger than the corresponding ASTM vehicle mass. A more detailed comparison of the vehicle properties and dimensions is provided in the appendix. Images of the vehicle types from each test standard are also provided in the appendix.

Vehicle Comparison

ASTM Test Vehicle/ Mass	PAS 68 Vehicle/ Mass	IWA 14 Vehicle/ Mass
SC: 1,100 kg	M1: 1,500 kg	M1: 1500 kg
FS: 2100 kg		
PU: 2,300 kg	N1-G: 2.500 kg	N1-G: 2500 kg
	N1: 3,500 kg	N1: 3500 kg
M: 6,800 kg	N2: 7,500 kg	N2- B: 7200 kg
C7: 7200 kg	N3: 7500 kg	N3-C: 7200 kg
		N3-D: 12000 kg
H: 29,500 kg *	NA	N3-E: 24000 kg
NA*	N3: 30000 kg	N3-F: 30000 kg

*These vehicles have significant differences (beyond the mass comparison). The ASTM and N3-E vehicle is representative of a three axle heavy vehicle (dump truck) while the PAS N3 and IWA N3-F vehicle is a loaded 4 axle delivery type truck.

Vehicle Impact Comparison

The vehicle impact speeds of the ASTM standards, the PAS 68, and IWA 14 can roughly be compared as shown in the following table. Also shown are the acceptable velocity range for each impact. Note that not all impact speed ratings are available for all vehicle sizes. Tables providing the available ratings are included in the appendix.

Vehicle Comparison

ASTM Impact Velocity Nominal (Range) kph	PAS 68 Impact Velocity Nominal (Range) kph	IWA 14 Impact Velocity Nominal (Range) kph
NA	16 (14-18)	16 (15-19)
NA	32 (30-34)	32 (31-35)
50 (45-60)	48 (45-51)	48 (47-51)
65 (60.1-75)	64 (61-67)	64 (63-67)
80 (75.1-90 or 75.1+*)	80 (75-85)	80 (78-84)
100 (90.1+)	96 (91-101)	96 (94-100)
NA	112 (107-117)	112 (110-116)
NA	16 (14-18)	16 (15-19)
NA	32 (30-34)	32 (31-35)

* If 60 mph rating is available, tolerance for ASTM 50 designation is 75.1-90 km/h; If 60 mph rating is not available, tolerance for ASTM 50 designation is 75.1 km/h and greater

Vehicle Impact Reference Point Comparison

The reference point on the vehicles noted in the ASTM standards, the PAS 68, and IWA 14 are generally comparable across the vehicle types with the exception of the Pickup Truck category. Each standard uses the “A Pillar” as the reference point for passenger cars. Each standard uses the leading edge of the truck bed for trucks other than the pickup truck. PAS and IWA treat the pickup truck as a passenger vehicle and use the “A Pillar” as the reference point. ASTM treats the truck as a cargo vehicle and uses the leading edge of the truck bed.

Design Guidance

Several entities do not have independent testing standards but refer to barrier testing or rating. For the US, these include the Department of Defense, the General Services Administration / Interagency Security Committee, the Federal Emergency Management Agency, the Department of Veteran Affairs, Customs and Border Patrol, and the New York Police Department.

Department of Defense

The DoD no longer has a proprietary rating system (the Navy had a rating system, but it is no longer in use). Performance requirements for specific projects are based on either the DoS or the ASTM testing standards and rating systems. The primary guidance document for barrier requirements of DoD

projects is UFC 4-022-02 *Selection and Application of Vehicle Barriers*. Additional information is also found in UFC-4-20-01 *Security Engineering: Facilities Planning Manual*, UFC 4-022-02 *Security Engineering: Concept Design* (FOUO), UFC 4-022-02 *Security Engineering: Final Design* (FOUO), and UFC 4-022- 01 *Security Engineering Entry Control Facilities/Access Control Points*.

While the DoS has a limited array of impact conditions and/or penetration ratings which are required for projects, the DoD has the ability to tailor specific project requirements to site, threat, and asset conditions. This includes acceptance of vehicle systems tested under the original DoS standard that resulted in higher penetrations if the site configuration allows.

US General Services Administration Ratings and Requirements

The General Services Administration first published their blast/security design criteria, *Draft GSA Security Design Criteria*, in 1998. Before this document was finalized, the Interagency Security Committee (ISC) was established and the GSA document was updated and published as the *Interagency Security Committee Security Design Criteria for New Federal Office Buildings and Major Modernization Projects* in May 2001. The applicable security document has since been updated to *The Risk Management Process for Federal Facilities: An Interagency Security Committee Standard* (inclusive of FOUO appendices).

The ISC document provides a baseline design vehicle mass and approach for determining the required rating as well as the baseline locations for providing the vehicle barriers. This information is FOUO. Refer to the design basis threat appendix for additional information. The baseline vehicle mass may be adjusted based on a site specific risk assessment. The baseline locations for the vehicle barriers varies based on the Facility Security Level (FSL). The ISC document specifies that the barriers be rated per either the 2007 edition of the ASTM testing standard or the 2003 edition of the State Department testing standard.

Federal Emergency Management Agency/Department of Homeland Security

The Federal Emergence Management Agency (FEMA) and US Department of Homeland Security (DHS) have a series of documents titled the Risk Management Series (RMS). Within this series of documents, they offer direction for assessment of vehicle threats and approaches for mitigating the threats. Although the documents typically refer to the DoS rating methodology (including the penetration levels of the original rating standards) in examples and discussion, they do not prescribe/require that vehicle mitigation measures be limited to this rating system.

Department of Veteran Affairs

The vehicle barrier requirements for the Department of Veteran Affairs are provided in *Physical Security Design Manual for VA Life-Safety Protected Facilities* and in *Physical Security Design Manual for VA Mission Critical Facilities.* The documents provide guidelines for barrier locations and identify the vehicle threat as a 4,000 pound (1,800 Kg) vehicle at a speed of 30 miles per hour (48 Km/hr) with a

maximum penetration distance of 3.3 feet (1m). This is slightly smaller than the ASTM FS30-P1 designation. The documents require that performance of anti-ram element be demonstrated by means of impact testing (either ASTM 2656-07 or DOS SD-STD-02.01, Revision A) or detailed finite element analysis of the vehicle impact.

Customs and Border Patrol

The Customs and Border Patrol requirements for vehicle barriers are provided in *CBP Security Policy and Procedures Handbook* (FOUO). The specifics of the design/applications are for official use only and can be obtained on a project specific document. The document references ratings in terms of DOS SD-STD-02.01, Revision A.

New York Police Department

The vehicle barrier requirements for New York City are provided in *New York City Police Department Engineering Security – Protective Design for High Risk Building*. The NYPD recommends that High Tier buildings conduct a site specific vehicle threat vector analysis and implement rated bollards. The referenced rating levels are based on DOS SD-STD-02.01, Revision A. However, equivalent ratings per the ASTM methodology to a P1 level are generally acceptable.

Appendix:

Car Comparison

Designation	ASTM-SC	ASTM-FS	PAS – M1	IWA-M1
Tested Mass (kg)	1110	2100	1500	1500
Tested Mass Tolerance (+/-kg)	25	50	50	75
Minimum Vehicle Mass (kg)	NA	NA	1234	1235
Maximum Ballast (kg)	NA	NA	266	265
Overall Length (mm)	NA	NA	4500	4500
Length Tolerance (+/- mm)	NA	NA	360	360
Wheelbase Length (mm)	NA	NA	2700	2700
Wheelbase Tolerance (+/- mm)	NA	NA	540	540
Width (mm)	NA	NA		1760
Width Tolerance (+/-mm)	NA	NA		150

Pick-up/Light Flatbed Comparison

Designation	ASTM-PU	PAS-N1G	PAS-N1	IWA-N1G	IWA-N1
Tested Mass (kg)	2270	2500	3500	2500	3500
Tested Mass Tolerance (+/-kg)	50	50	100	75	100
Minimum Vehicle Mass (kg)	NA	1620	1675	1700	1675
Maximum Ballast (kg)	NA	880	1825	800	1825
Overall Length (mm)	NA	4900	6200	5200	6200
Length Tolerance (+/- mm)	NA	320	380	600	380
Wheelbase Length (mm)	NA	2900	3805	3200	3805
Wheelbase Tolerance (+/- mm)	NA	580	710	500	710
Width (mm)	NA	NA	NA	1850	2100
Width Tolerance(+/- mm)	NA	NA	NA	200	175
Frame Clearance (mm)	NA	NA	NA	435	440
Frame Clearance Tolerance (+/-mm)	NA	NA	NA	75	120

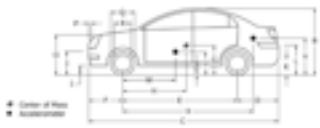
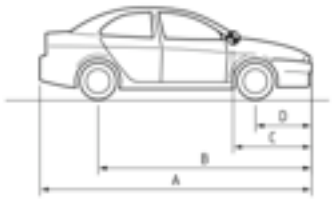
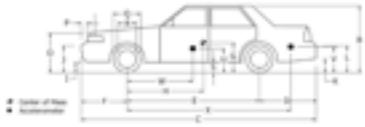
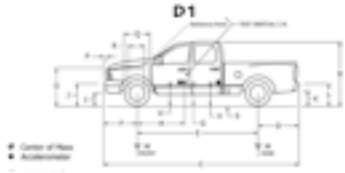
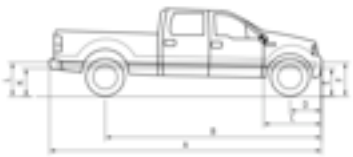
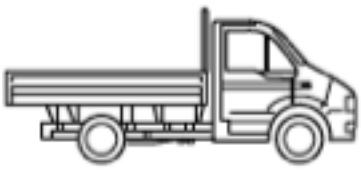
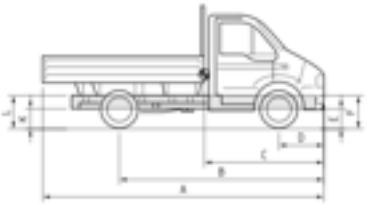
2 Axle Truck Comparison

Designation	ASTM-M	ASTM-C7	PAS-N2	PAS-N3	IWA-N2A	IWA-N2B	IWA-N3C	IWA-N3D
Tested Mass (kg)	6800	7200	7500	7500	7200	7200	7200	12000
Tested Mass Tolerance (+/-kg)	140	150	150	150	400	400	400	400
Minimum Vehicle Mass (kg)	NA	NA	3575	6100	3575	5200	6100	6200
Maximum Ballast (kg)	NA	NA	3925	1400	3625	2000	1100	5800
Overall Length (mm)	NA	NA	7612	9557	7610	8340	9560	8900
Length Tolerance (+/- mm)	NA	NA	1522	1911	1520	1670	1910	1900
Wheelbase Length (mm)	6000	6000	4310	5907	4310	5275	5910	5450
Wheelbase Tolerance (+/- mm)	1250	1250	830	1250	830	1100	1250	1250
Width (mm)	NA	NA	NA	NA	2400	2400	2500	2500
Width Tolerance (+/- mm)	NA	NA	NA	NA	200	200	225	225
Frame Clearance (mm)	NA	NA	NA	NA	515	630	750	845
Frame Clearance Tolerance (+/-mm)	NA	NA	NA	NA	175	175	200	225

3/4 Axle Truck Comparison

Designation	**3 Axle**		**4 Axle**	
	ASTM-H	IWA-N3-E	PAS-N3	IWA -N3-F
Tested Mass (kg)	29500	24000	30000	30000
Tested Mass Tolerance (+/-kg)	590	400	600	400
Minimum Vehicle Mass (kg)	NA	9750	10500	10500
Maximum Ballast (kg)	NA	14250	19500	19500
Overall Length (mm)	NA	7640	10240	9600
Length Tolerance (+/- mm)	NA	1200	500	1000
Wheelbase Length (mm)	NA	5600	6500	6800
Wheelbase Tolerance (+/- mm)	NA	500	200	500
Width (mm)	NA	2400	NA	2500
Width Tolerance(+/- mm)	NA	200	NA	225
Frame Clearance (mm)	NA	750	NA	810
Frame Clearance Tolerance (mm)	NA	200	NA	200

Test Standard Vehicle Image Comparison for Cars and Pick-up/Light Flatbed

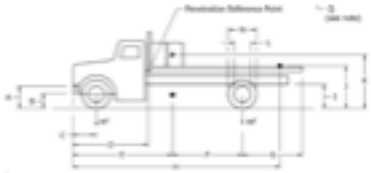
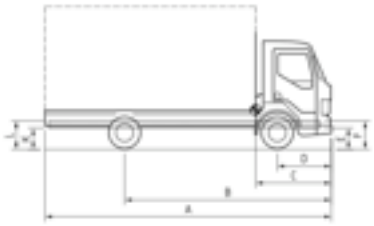
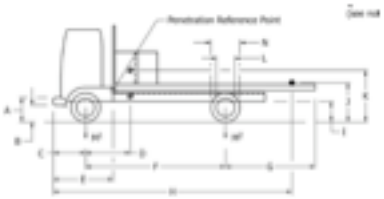
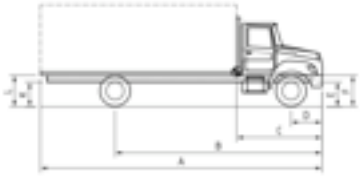
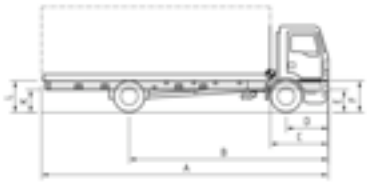
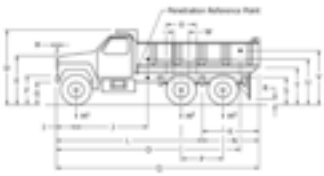
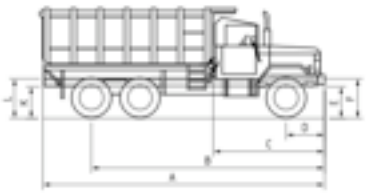
ASTM*	PAS**	IWA***
SC 	M1 	M1 
FS 		
P1 	N1G 	N1G 
	N1 	N1 

*Reference *Standard Test Method for Vehicle Crash Testing of Vehicle Security Barriers*, Standard F-2656-18a

**Reference BSI Publicly Available Specification: PAS 68/69:2013, *Impact Test Specifications for Vehicle Security Barrier Systems* and *Guidance for the Selection, Installation and Use of Vehicle Security Barrier Systems*.

***Reference ISO International Workshop Agreement (IWA) 14-1/2, *Vehicle Security Barriers – Part 1: Performance Requirement, Vehicle Impact Test Method and Performance Rating* and *Vehicle Security Barriers – Part 2: Application*.

Test Standard Vehicle Image Comparison for 2, 3, and 4 Axle Trucks

ASTM*	PAS**	IWA***
M 	N2 	N2A 
C7 		N2B 
	N3 	N3C/N3D 
H 		N3E 
	N3 	N3F 

*Reference *Standard Test Method for Vehicle Crash Testing of Vehicle Security Barriers*, Standard F-2656-18a

**Reference BSI Publicly Available Specification: PAS 68/69:2013, *Impact Test Specifications for Vehicle Security Barrier Systems* and *Guidance for the Selection, Installation and Use of Vehicle Security Barrier Systems*.

***Reference ISO International Workshop Agreement (IWA) 14-1/2, *Vehicle Security Barriers – Part 1: Performance Requirement, Vehicle Impact Test Method and Performance Rating* and *Vehicle Security Barriers – Part 2: Application*.

Available Nominal Impact Velocity Ratings

	16 kph	32 kph	50/48 kph*	65/64 kph**	80 kph	100/96 kph**	112 kph
ASTM-SC	No	No	Yes	Yes	Yes	Yes	No
ASTM-FS	No	No	Yes	Yes	Yes	Yes	No
PAS - M1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IWA-M1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ASTM-PU	No	No	Yes	Yes	Yes	Yes	No
PAS-N1G	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PAS-N1	Yes	Yes	Yes	Yes	Yes	Yes	No
IWA- N1G	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IWA- N1	Yes	Yes	Yes	Yes	Yes	Yes	No
ASTM-M	No	No	Yes	Yes	Yes	No	No
PAS-N2	Yes	Yes	Yes	Yes	Yes	No	No
IWA-N2A	Yes	Yes	Yes	Yes	Yes	No	No
IWA-N2B	Yes	Yes	Yes	Yes	Yes	No	No
ASTM-C7	No	No	Yes	Yes	Yes	No	No
PAS-N3	Yes	Yes	Yes	Yes	Yes	No	No
IWA-N3C	Yes	Yes	Yes	Yes	Yes	No	No
IWA-N3D	Yes	Yes	Yes	Yes	Yes	No	No
ASTM-H	No	No	Yes	Yes	Yes	No	No
IWA N3-E	Yes	Yes	Yes	Yes	Yes	No	No
PAS-N3	Yes	Yes	Yes	Yes	Yes	No	No
IWA N3-F	Yes	Yes	Yes	Yes	Yes	No	No

*50 kph nominal for ASTM, 48 kph nominal for IWA/BSI

**65 kph nominal for ASTM, 64 kph nominal for IWA/BSI

***100 kph nominal for ASTM, 96 kph nominal for IWA/BSI